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ORIGINAL ARTICLE

Intake of different alcoholic beverages and periodontal condition

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ABSTRACT

Objective: The objective of this study is to study the association of alcoholic beverages and serum gamma-glutamyltransferase (GGT) level with periodontal condition.

Material and methods: The study included 4294 dentate, non-diabetic Finnish adults aged 30−65 years who underwent periodontal examination during the Health 2000 Survey. The number of teeth with deepened (≥4 mm) periodontal pockets was the outcome. The exposures were self-reported beverage-specific alcohol intake (amount and frequency) and serum GGT level. The relative risks (RRs) and 95% confidence intervals (CI) were obtained by fitting zero-inflated negative binomial regression models.

Results: We found no consistent association of either the intake of different alcoholic beverages or GGT level with the number of teeth with deepened periodontal pockets in the total study population or among the non-smokers. Among the highly educated non-smokers, spirit intake was associated with a low likelihood of having teeth with deepened periodontal pockets; RRs varied between 0.3 and 0.8. Among the non-smokers who had basic or intermediate education, spirit intake was associated with a higher likelihood of having teeth with deepened periodontal pockets; RRs varied between 1.2 and 1.8.

Conclusion: In general, neither the intake of different alcoholic beverages nor the GGT level was consistently associated with the number of teeth with deepened periodontal pockets.

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Alcoholic beverages; frequency of alcohol intake; amount of alcohol intake; periodontal disease; socioeconomic position

Introduction

Earlier studies have documented the effects of alcohol use on health. These health effects appears to be dependent on different dimensions of alcohol use such as the volume, drinking patterns [1,2], or intake of specific alcoholic beverages [3,4]. Also, the effects of alcohol use on oral health, particularly periodontal health, have been widely studied. Most of this research was focused on addressing the question of whether the amount and frequency of alcohol use is associated with different periodontal disease outcomes [5–10].

Despite numerous studies, the question of whether the intake of different types of alcoholic beverages is associated with periodontal health is still unanswered [11]. This is because of conflicting results: some of the earlier reports have suggested that there is no association between the intake of different alcoholic beverages and periodontal parameters [6,12] while others have reported that the use of certain alcoholic beverages is associated with either poor [13] or good periodontal condition [14].

It is known that apart from the biological effects, choice of beverage and lifestyle factors associated with the intake of specific beverages could also partly explain the effects of these beverages. It has been suggested that wine drinking is associated with higher social status whereas beer drinking is associated with lower social status [15]. In addition, it has been reported that individuals belonging to the higher educational groups had less alcohol-related consequences than those belonging to the lower educational groups. Somewhat surprisingly, this phenomenon was reported to be independent of drinking patterns [16].

Due to the limited evidence on the association of different alcoholic beverages with periodontal condition to date, data from a nationwide survey were used in this study to investigate whether different alcoholic beverages associate differently with periodontal condition. It was hypothesized that this could explain the previously reported non-consistent association between alcohol consumption and periodontal condition in these same data [17,18]. Based on the previous literature on the harmful effects of spirit intake on general health, the hypothesis was that the effects of spirit intake are more harmful to periodontal health than beer or wine. Hence, the aim of this study was to investigate whether the intake (amount and frequency) of specific alcoholic beverages (wine, spirits, beer/cider/long drinks) and

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gamma-glutamyltransferase (GGT) levels associated with the periodontal condition measured by the presence of deepened (≥4 mm) periodontal pockets.

Material and methods

Study population

The study is a part of the Health 2000 Survey, which was carried out on a nationally representative Finnish population aged ≥30 years in 2000–2001 by the National Institute for Health and Welfare (THL) (formerly the National Public Health Institute [KTL] of Finland). This survey had a two-stage stratified cluster sampling frame of 8,028 adults, out of which 88% participated in an interview and 79% ($n = 6342$) attended a comprehensive health examination including a clinical oral examination ($n = 6335$). The survey collected information through interviews, self-administered questionnaires, and clinical health examinations including oral health examinations and laboratory measurements. All participants gave their written informed consent to participate in the survey. The research plan for the survey was approved by the Ethical Committee for Research in Epidemiology and Public Health at the hospital district of Helsinki and Uusimaa. More information about the Health 2000 Survey is available in the reports by Aromaa and Koskinen [19] and Heistaro [20].

In this cross-sectional study, 4294 dentate (having at least one natural tooth) non-diabetic subjects aged 30–65 years from the Health 2000 Survey, whose periodontal condition was measured, were included. Out of 6335 participants who took part in the clinical oral examination, periodontal condition of those who were in need of antibiotic prophylaxis was not examined. The remaining 5225 participants whose periodontal health information was available were included in this study. The sample was further reduced when participants who were aged >65 years ($n = 665$) followed by those who had diabetes ($n = 266$) were excluded, resulting in a sample size of 4294 dentate participants.

Information about diabetes was obtained from the health interview and the health examination. The non-diabetic subjects included those who reported during the health interview that they had not been diagnosed as having diabetes by a physician previously, and whose fasting glucose was <7.0 mmol/l, and/or in a situation where the fasting glucose was normal and the blood glucose concentration was <11.1 mmol/l after a standard oral glucose tolerance test during the clinical health examination. This manuscript is in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for human observational studies.

Outcome variable

Five trained and calibrated dentists measured periodontal pocket depths at four predetermined sites (distobuccal, midbuccal, midpalatal/lingual, and mesiopalatal/lingual) on each tooth (excluding third molars and tooth remnants) during the clinical oral examination. The dentists performed the oral examinations in a dental chair using a headlamp, mouth mirror, fibre optic light (Novar, Finland), a fibre optic headlamp (Tekmala, Finland) and a WHO periodontal probe with a probing force of 20 g (calibrated using a letter scale). The deepest probing depth was registered for each tooth as no deepened periodontal pockets, periodontal pockets 4–5 mm deep, or periodontal pockets ≥6 mm. The outcome variable, which in this study indicates the periodontal condition of the participants, the number of teeth with deepened (≥4 mm) periodontal pockets, was formed by combining the last two categories. The parallel and repeat pocket measurements were performed to assess the concordance between the examiners and the reproducibility of the measurements. Parallel measurements between the field examiners and the reference examiner yielded a perpetual agreement of 77% and κ-value of 0.41. Intra-examiner repeat measurements yielded a κ-value of 0.83 [21,22].

Explanatory variables

Information about the amount and frequency of the intake of different alcoholic beverages was obtained from a self-report questionnaire. The participant's average amount of intake per week during the last month was assessed separately for each beverage type (wine, spirits, and beer/cider/long drinks). Subsequently, the average weekly intake (amount) of different alcoholic beverages during the last month was converted to average alcohol intake in grams/week for each type of beverage by the investigators according to the estimation of portions indicated in the Health 2000 Survey questionnaire. The six answer options of wine intake per week during the last month were: not at all, less than one glass (8–12 cl), 1–4 glasses, from 0.5 to 3 bottles, 3–5 bottles, and >5 whole bottles. The answer options for average spirits intake per week during the last month were as follows: not at all, <1 glass (4 cl), 1–6 glasses, half a bottle–2 half-litre bottles, 2 half-litre bottles–4 half-litre bottles and ≥4 half-litre bottles. The average weekly intake of beer/cider/long drinks during the last month was recorded by the number of bottles as: not at all, and the number of bottles. This variable was used both as a continuous variable and a categorical variable with three categories: not at all, ≤23.8 g/week and >23.8 g/week. Further information about alcohol use measures can be obtained from the Health 2000 questionnaire (https://thl.fi/documents/189940/4108213/T2002_eng.pdf/83a57f85-0acb-4b25-af7d-29d7bf4b2282).

To assess the frequency of the intake of each beverage separately (wine, spirits and beer/cider/long drinks), an identical question was asked for each type of beverage 'How often did you drink during the last 12 months?' The response options were: never, weekly intake (6–7 times, 4–5 times, 2–3 times and once), monthly intake (a couple of times, once, once every couple of months) and yearly intake (3–4 times a year, once or twice a year). For the statistical analyses, five categories were made for each beverage type by combining response options: never, about once a month to once or twice a year, a couple of times a month to once a week, 2–3 times a week, and 4–7 times a week.

In addition to the self-reported intake of alcoholic beverages, alcohol intake was assessed using serum GGT level, which is a commonly used biological marker for identifying alcohol use. The serum samples were collected and the serum concentration of GGT in IU/L was analysed using a kinetic method (IFCC/ECCLS, Konelab, Thermo Electron Oy, Vantaa, Finland).

Covariates

Socio-demographic variables included age (continuous variable) and gender. The participants' level of education served as a measure of socioeconomic position (SEP), which was categorized into three groups based on the interview: basic (below upper secondary or vocational school level), intermediate (graduated from upper secondary school or vocational school) and higher (graduated from university or polytechnics). Body mass index (BMI, kg/m^2) was calculated based on the information on weight and height obtained during the clinical health examination. In case of the absence of such information, information from a questionnaire was used [20].

A modified version of the method described by Silness and Löe [23] was used to assess the presence of dental plaque. Dental plaque was recorded from one surface of three predetermined teeth: the buccal surface of the most posterior tooth on the right side of the maxilla, the lingual surface of the most posterior tooth on the left side of the mandible, and the buccal surface of the lower left canine (lower right canine, if the lower left canine was absent). The presence of plaque on three index teeth was noted as no plaque, plaque only in gingival margin, or plaque also elsewhere, and the highest value from any of the index teeth indicated the oral hygiene status of the participant.

Participants reported about their toothbrushing frequency during an interview as follows: twice a day or more, once a day, and less frequently. During the interview, participants were also questioned 'Do you usually go to a dentist?' and they responded about their dental attendance pattern as follows: for regular check-ups, only when you have a toothache or some other trouble, and never. The last two categories were combined for the statistical analyses: regular check-ups versus irregular dental attendance. The smoking habits of the participants were categorized as follows: daily, occasional and non-smoker. Information about the use of lipid-lowering drugs and non-steroidal anti-inflammatory drugs (NSAIDs) were obtained from the health interview and were categorized as yes versus no. A third category, missing information, was created during the analyses for those who did not answer the question.

A previous study suggested C-reactive protein (CRP) as one of the modifiable risk factors for periodontitis [24]. In this study, serum CRP level was used as a covariate to assess the systemic inflammatory state. The serum samples were collected in small tubes by pipettes, were first clotted by placing samples on the table, and then centrifuged and frozen at −20 °C. The CRP levels (mg/L) were then quantified using an automated analyzer (Optima, Thermo Fisher Scientific Oy, Vantaa, Finland) and an ultrasensitive immunoturbidimetric test (Ultrasensitive CRP, Orion Diagnostica, Espoo, Finland).

Statistical analyses

Relative risks (RR) along with 95% confidence intervals (95% CI) were estimated by fitting zero-inflated negative binomial regression models. The model examined the association of the exposure variable, in this case various alcoholic beverages or GGT, with the outcome variable (the number of teeth with deepened periodontal pockets) in two parts. The first negative binomial part (including covariates and the offset option) and the second part is the zero-inflated part for the excess zeroes including the covariates. Subjects with missing data for any of the variables were automatically excluded during the regression analyses (except the use of lipid-lowering drugs and NSAIDs, where a missing information category was created).

The regression analyses in the total population were adjusted for age (continuous), gender, level of education, toothbrushing frequency, the presence of plaque, dental attendance pattern, BMI (continuous), smoking, the use of lipid lowering drugs, the use of NSAIDs, CRP (continuous) and for other types of alcoholic beverages. The number of teeth in a log form served as an offset variable in the regression analyses. We repeated similar analyses among the non-smokers, and also performed stratified analyses by educational level among the non-smokers. These stratified analyses among the non-smokers were adjusted for all of the above-mentioned covariates except the level of education. In these stratified analyses, we combined the basic and intermediate education categories (lower education) due to a small number of participants in these categories.

STATA V.13.0 (Stata Corp, College Station, TX, USA) was used in all statistical analyses to take into account the two-stage sampling design of the Health 2000 Survey, and the post-stratification weights were used to correct for non-response [19]. The post-stratum weights were based on age, gender, and region. Statistical significance was set at a p-value level of 0.05 in all of the analyses.

Results

Tables 1 and 2 present the basic characteristics of the study population.

Total population

In the total study population, relative risks of the association among the amount of wine, spirit and beer/cider/long drink intake and the number of teeth with deepened (≥4 mm) periodontal pockets varied between 0.3 and 1.0, 0.7 and 1.0, and 1.0 and 1.1, respectively. Moreover, relative risks for the association of the intake frequency of different alcoholic beverages with the number of teeth with deepened periodontal pockets varied between 1.0 and 1.2. Most of the above-mentioned associations were not statistically significant. The GGT

Table 1. Characteristics of the study participants according to the number of teeth with deepened (≥4 mm) periodontal pockets.

	All ($n = 4294$)	No teeth with deepened (≥4 mm) pockets ($n = 1608$)	≥1 teeth with deepened (≥4 mm) pockets ($n = 2686$)
Age, mean (SD)	45.7 (9.5)	44.0 (9.6)	46.7 (9.3)
Gender (%)			
Male	49.3	39.1	55.2
Female	50.7	60.9	44.8
Level of education (%)	($n = 4276$)	($n = 1603$)	($n = 2673$)
Basic	26.9	24.9	28.1
Intermediate	37.4	35.7	38.4
High	35.7	39.4	33.6
Presence of plaque (%)	($n = 4267$)	($n = 1592$)	($n = 2675$)
No plaque	37.6	51.8	29.4
In gingival margins	50.3	42.3	54.9
Also elsewhere	12.1	5.9	15.7
Toothbrushing frequency (%)	($n = 4136$)	($n = 1543$)	($n = 2593$)
≥Twice a day	63.3	67.2	61.0
Once a day	30.3	28.9	31.1
Less frequently	6.5	3.9	7.9
Dental attendance pattern (%)	($n = 4139$)	($n = 1544$)	($n = 2595$)
Regular	60.8	63.8	59.0
Irregular	39.3	36.2	41.0
Body mass index (kg/m^2), mean (SD)	($n = 4292$) 26.4(4.4)	($n = 1608$) 26.1(4.4)	($n = 2684$) 26.6(4.4)
Use of lipid-lowering drugs (%)	($n = 4294$)		
No	87.5	89.4	86.4
Yes	3.4	2.9	3.6
Missing information	9.1	7.7	10.0
Use of non-steroidal anti-inflammatory drugs (%)	($n = 4294$)		
No	53.4	53.3	53.5
Yes	37.5	39.1	36.5
Missing information	9.1	7.7	10.0
Smoking (%)	($n = 4277$)	($n = 1603$)	($n = 2674$)
Daily smoker	25.1	18.5	28.9
Occasional smoker	6.8	6.6	7.0
Non-smoker	68.1	74.9	64.1
Total number of teeth, mean (SD)	24.4 (6.7)	24.0 (7.5)	24.6 (6.2)
Number of teeth with periodontal pockets ≥4 mm, mean (SD)	4.1 (5.6)	0	6.6 (5.8)
C-reactive protein (mg/L), mean (SD)	($n = 4246$) 1.8 (4.5)	($n = 1595$) 1.7 (4.6)	($n = 2651$) 1.8 (4.4)

SD: standard deviation.

levels in this study population were not associated with the number of teeth with deepened periodontal pockets (Table 3).

Non-smoking population

Among the non-smokers, the association of different alcoholic beverages (both amount and frequency) or GGT levels with the number of teeth with deepened periodontal pockets followed a similar pattern except that there was more variation in the risk estimates. Relative risks for the association of the amount and frequency of intake of different beverages with the number of teeth with deepened periodontal pockets ranged from 0.5 to 1.3 and 0.9 to 1.4, respectively. Most of the above-mentioned associations were not statistically significant (Table 4).

Stratified analyses among non-smokers according to their level of education

A large variation in the risk estimates was observed in the association of the amount and frequency of the intake of different alcoholic beverages with the number of teeth with deepened periodontal pockets between educational groups. There was no clear association between the amounts of intake of any of the alcoholic beverages with the number of teeth with deepened periodontal pockets; most of the risk estimates were close to 1. The risk estimates of the amount variable were more conservative as compared to the frequency variable. There was practically no association of GGT with the number of teeth with deepened periodontal pockets in any of these groups (Table 4).

The frequency of spirit intake was associated, although inconsistently, with the number of teeth with deepened periodontal pockets. Participants with higher education who consumed spirits had a lower likelihood of having teeth with deepened periodontal pockets compared to those who did not use at all (risk estimates ranged from 0.3 to 0.8), while participants belonging to basic or intermediate educational groups who consumed spirits had a higher likelihood of having teeth with deepened periodontal pockets compared to non-drinkers (risk estimates ranged from 1.2 to 1.8). Some of these associations were statistically significant (Table 4).

Frequency of beer/cider/long drink intake was associated with the number of teeth with deepened periodontal pockets among the higher educational group (risk estimates varied between 1.3 and 1.4) and mostly inversely in the combined group of those belonging to the basic or intermediate educational group (risk estimates varied between 0.8 and 1.0). None of these associations were statistically significant (Table 4).

Table 2. Intake of different alcoholic beverages according to the number of teeth with deepened (≥4 mm) periodontal pockets.

Alcoholic beverages use measures	All ($n = 4294$)	No teeth with deepened (≥4 mm) pockets ($n = 1608$)	≥1 teeth with deepened (≥4 mm) pockets ($n = 2686$)
Average wine intake during the last month (%)	($n = 4230$)	($n = 1591$)	($n = 2639$)
Not at all	47.0	48.6	46.0
<1 glass (8-12 cl) a week	22.3	22.6	22.1
1–4 glasses a week	22.2	22.4	22.0
0.5–3 bottles a week	7.7	5.7	8.9
3–5 bottles a week	0.7	0.5	0.9
>5 whole bottles a week	0.2	0.1	0.2
Average spirits intake during the last month (%)	($n = 4213$)	($n = 1588$)	($n = 2625$)
Not at all	48.4	53.1	45.6
<1 glass (4 cl) a week	26.0	26.6	25.7
1–6 glasses a week	20.2	17.6	21.7
Half a bottle–2 half-litre bottles	3.4	1.8	4.4
2 half-litre bottles to 4 half-litre bottles	1.5	1.0	1.9
4 half-litre bottles or more	0.5	0	0.8
Average beer/cider/long drinks intake g/week during the last month (%)	($n = 4175$)	($n = 1580$)	($n = 2595$)
Not at all	37.8	40.6	36.1
≤23.8	27.5	30.3	25.9
>23.8	34.7	29.1	38.0
Average beer/cider/long drinks intake g/week during the last month (continuous), mean (SD)	40.2 (71.8)	31.2 (54.3)	45.4 (79.9)
Gamma-glutamyltransferase level (IU/L), mean (SD)	($n = 4283$)	($n = 1604$)	($n = 2679$)
	35.1 (38.8)	31.1 (36.7)	37.5 (39.7)
Frequency of wine intake during the last 12 months (%)	($n = 3822$)	($n = 1425$)	($n = 2397$)
Never	18.8	18.1	19.2
About once a month to once/twice a year	46.6	48.7	45.3
Couple of times a month to once a week	28.2	28.0	28.3
2 to 3 times a week	5.9	4.9	6.5
4 to 7 times a week	0.6	0.4	0.7
Frequency of spirits intake during the last 12 months (%)	($n = 3849$)	($n = 1432$)	($n = 2417$)
Never	15.2	17.6	13.8
About once a month to once/twice a year	55.7	58.3	54.1
Couple of times a month to once a week	24.6	20.7	26.8
2–3 times a week	3.9	3.0	4.5
4–7 times a week	0.6	0.4	0.8
Frequency of beer/cider/long drinks intake during the last 12 months (%)	($n = 3855$)	($n = 1434$)	($n = 2421$)
Never	4.7	4.8	4.7
About once a month to once/twice a year	28.2	31.8	26.1
Couple of times a month to once a week	41.8	41.4	42.1
2–3 times a week	19.6	17.0	21.1
4–7 times a week	5.7	4.9	6.1

SD: standard deviation.

Discussion

The results in the total study population revealed that, contrary to our hypothesis, there was no consistent association of either the intake of different alcoholic beverages (amount or frequency) or GGT levels with the number of teeth with deepened (≥4 mm) periodontal pockets. In a similar manner, there was practically no association with the number of teeth with deepened periodontal pockets among the non-smoking population. However, we found that the strength of the association of the intake of alcoholic beverages, especially frequency (spirit and beer/cider/long drink), with the number of teeth with deepened periodontal pockets was dependent on participants' educational level.

Strengths and weaknesses of this study

One of the major strengths of this study is the large study population with a high participation rate [19]. Additionally, confounding was controlled for by using multivariate models and restrictions (age and diabetes). Contrary to some of the earlier studies, we have also used stratification as a method to control for smoking and SEP.

In contrast to the previous studies, which have investigated the association using net alcohol consumption as an exposure, we used both the amount and frequency of the intake of different alcoholic beverages as exposure variables. Despite these efforts, it is evident that the underreporting of alcohol consumption can be an inherent limitation in this study like it is in most epidemiological studies focusing on the effects of alcohol based on self-reported data. To overcome this problem, we also used GGT as an exposure, which is a biological marker for alcohol use. GGT has been shown to have the highest validity compared to other markers, namely mean corpuscular volume (MCV), aspartate aminotransferase (AST), alanine aminotransferase (ALT) and carbohydrate-deficient transferrin (CDT) [25]. Additionally, the fairly small number of heavy drinkers in these data – confirmed by a quite low mean GGT level in the total study population, i.e. 35.1 IU/L – is likely to reduce the bias related to self-reported alcohol measurements, as it is known that heavy drinkers underreport their alcohol consumption more than light or moderate drinkers.

Table 3. Association of intake of different alcoholic beverages (amount and frequency) and Gamma-glutamyltransferase levels with the number of teeth with deepened (≥4 mm) periodontal pockets in the study population.

Alcohol use	RR (95% CI)
Average wine intake during the last month[a]	(*n* = 3912)
Not at all	1
<1 glass (8-12 cl) a week	**0.9 (0.8−1.0)**
1–4 glasses a week	1.0 (0.9−1.1)
0.5–3 bottles a week	1.0 (0.9−1.2)
3–5 bottles a week	0.8 (0.4−1.3)
>5 whole bottles a week	**0.3 (0.1−0.8)**
Average spirits intake during the last month[b]	(*n* = 3912)
Not at all	1
<1 glass (4 cl) a week	1.0 (0.9−1.1)
1–6 glasses a week	1.0 (0.9−1.1)
Half a bottle–2 half-litre bottles	1.0 (0.8−1.3)
2 half-litre bottles to 4 half-litre bottles	1.0 (0.8−1.3)
4 half-litre bottles or more	**0.7 (0.5−1.0)**
Average beer/cider/long drinks intake g/wk. during the last month[c]	(*n* = 3912)
Not at all	1
≤23.8	1.0 (0.8–1.1)
>23.80	**1.1 (1.0–1.2)**
Average beer/cider/long drinks intake g/wk. during the last month[c] (continuous)	(*n* = 3912) 1.00 (1.00–1.00)
Gamma-glutamyltransferase level (IU/L)	(*n* = 4060) **1.00 (1.00–1.00)**
Frequency of wine intake during the last 12 months[d]	(*n* = 3598)
Never	1
About once a month to once/twice a year	1.0 (0.9–1.1)
Couple of times a month to once a week	1.0 (0.9–1.1)
2–3 times a week	**1.1 (1.0–1.4)**
4–7 times a week	1.1 (0.7–1.6)
Frequency of spirits intake during the last 12 months[e]	(*n* = 3598)
Never	1
About once a month to once/twice a year	1.1 (0.9–1.2)
Couple of times a month to once a week	1.0 (0.8–1.1)
2–3 times a week	**1.2 (1.0–1.5)**
4–7 times a week	1.1 (0.7–1.6)
Frequency of beer/cider/long drinks intake during the last 12 months[f]	(*n* = 3598)
Never	1
About once a month to once/twice a year	1.1 (0.9–1.4)
Couple of times a month to once a week	1.1 (0.9–1.3)
2–3 times a week	1.1 (0.9–1.4)
4–7 times a week	1.0 (0.8–1.3)

Adjusted relative risk (RR) with 95% confidence interval (95% CI).
Model 1: Adjusted for age, gender, education, smoking, Body mass index (continuous), the use of non-steroidal anti-inflammatory drugs, the use of lipid-lowering drugs, the presence of plaque, dental attendance pattern, tooth-brushing frequency, C-reactive protein (continuous), and log form of number of teeth as offset variable.
[a]Adjusted for Model 1 + the average spirit intake and the average intake of beer/cider/long drinks (continuous).
[b]Adjusted for Model 1 + the average wine intake and the average intake of beer/cider/long drinks (continuous).
[c]Adjusted for Model 1 + the average wine intake and the average spirit intake.
[d]Adjusted for Model 1 + the intake frequency of spirits and beer/cider/long drinks.
[e]Adjusted for Model 1 + the intake frequency of wine and beer/cider/long drinks.
[f]Adjusted for Model 1 + the intake frequency of wine and spirits.
Statistically significant values ($p < .05$) are in bold.

One limitation of this survey was that the periodontal condition was assessed solely by periodontal pocket depth measurement. Nevertheless, the number of teeth with deepened periodontal pockets has been found to be related to a number of risk factors, such as overweight or obesity [26], insulin resistance [27] and smoking [28] in an expected manner in these data. Moreover, periodontal pocket depth reflects the present inflammatory condition while measures using combined criteria including clinical attachment loss and pocket depth put more weight to the disease history [29]. In this context, it is important to note, however, that although the outcome, the number of teeth with deepened periodontal pockets, measures the extent of inflammation in the periodontium; it does not correspond with the clinical diagnosis of chronic periodontitis. The cut-off value for deepened periodontal pocket in this survey was pre-set to 4 mm, which is commonly used in epidemiological studies and clinical practice. Regarding quality of periodontal examination, repeat and parallel measurements yielded moderate inter-examiner reliability and high intra-examiner reliability for periodontal pocket measurement [21,22].

Lastly, it is worth noting that there are few participants who drink a lot, and our conclusions about the intake of different alcoholic beverages and periodontal health are, therefore, valid for those individuals who are light-to moderate drinkers. It is also self-evident that non-experimental study design is a limitation which prevents us from making any causal inferences.

Comparison with other studies

The main finding of this study, namely that different alcoholic beverages had no essential association with the number of teeth with deepened periodontal pockets, maps well to the findings of a previous cross-sectional study by Tezal et al. [12] who reported that the type of alcoholic beverage was not associated with various periodontal health outcomes, and of the 4-year follow-up study by Pitiphat et al. [6] with similar results. Although Pitiphat et al. [6] did not report any consistent associations, they reported beer and red wine intake to be weakly associated with periodontitis risk.

In contrast to the above-mentioned studies, Tezal et al. [13] later reported that beer and hard liquor were associated with poor periodontal health. This observation corresponds with what was found in these data about the intake of beer among the higher educational group, where the risk estimates for the frequency of intake of beer/cider/long drink varied between 1.3 and 1.4. By contrast, at the same time, among the lower educational group (the combined group comprising participants with basic and intermediate education), the results were quite the opposite – risk estimates varied between 0.8 and 1.0.

Explanation of findings and possible mechanisms

The fact that the association of the frequent spirit intake with periodontal health (either negative or positive) was dependent on participants' education level suggests that besides the effects of the type of alcoholic beverages, the factors related to SEP (such as lifestyle and health behaviour) determines whether the effect is beneficial, null or harmful. This means that the often-suggested beneficial effects of alcohol, for example, the effects of wine intake on health,

Table 4. Association of intake of different alcoholic beverages (amount and frequency) and Gamma-glutamyltransferase levels with the number of teeth with deepened (≥4 mm) periodontal pockets among non-smokers and stratified by level of education among the non-smokers.

	RR (95 % CI)		
Alcohol use	Non smokers	Non-smokers: basic or intermediate education	Non-smokers: higher education
Average wine intake during the last month[a]	(*n* = 2681)	(*n* = 1589)	(*n* = 1092)
Not at all	1	1	1
<1 glass (8-12 cl) a week	0.9 (0.8−1.1)	0.9 (0.7−1.1)	1.1 (0.8−1.4)
1–4 glasses a week	1.0 (0.8−1.1)	0.9 (0.8−1.1)	1.1 (0.9−1.4)
0.5–3 bottles a week	**1.2 (1.0−1.5)**	1.1 (0.8−1.5)	**1.4 (1.0−2.0)**
3–5 bottles a week	0.5 (0.2−1.2)	**0.1 (0.0−0.3)**	0.9 (0.3−2.3)
>5 whole bottles a week	0.8 (0.6−1.1)	–	0.9 (0.5−1.6)
Average spirits intake during the last month[b]	(*n* = 2681)	(*n* = 1589)	(*n* = 1092)
Not at all	1	1	1
<1 glass (4 cl) a week	1.0 (0.9−1.1)	1.1 (0.9−1.3)	0.9 (0.7−1.1)
1–6 glasses a week	1.0 (0.9−1.2)	**1.2 (1.0−1.4)**	0.8 (0.6−1.1)
Half a bottle–2 half-litre bottles	**1.3 (1.0−1.7)**	**1.4 (1.0−2.0)**	0.9 (0.5−1.6)
2 half-litre bottles to 4 half-litre bottles	1.0 (0.7−1.5)	1.1 (0.7−1.6)	**0.3 (0.1−0.6)**
4 half-litre bottles or more	0.9 (0.3−2.3)	0.8 (0.3–2.0)	———————
Average beer/cider/long drinks intake g/wk. during the last month[c]	(*n* = 2681)	(*n* = 1589)	
Not at all	1	1	
≤23.8	1.0 (0.8–1.1)	1.1 (0.9–1.3)	———————
>23.8	1.0 (0.9–1.2)	1.1 (0.9–1.3)	
Average beer/cider/long drinks intake g/wk. during the last month[c] (continuous)	(*n* = 2681)	(*n* = 1589)	(*n* = 1092)
	1.00 (1.00–1.00)	**1.00 (1.00–1.00)**	**1.00 (1.00–1.00)**
Gamma-glutamyltransferase level (IU/L)	(*n* = 2771)	(*n* = 1660)	(*n* = 1111)
	1.00 (1.00–1.00)	**1.00 (1.00–1.00)**	**1.00 (1.00–1.00)**
Frequency of wine intake during the last 12 months[d]	(*n* = 2402)	(*n* = 1404)	(*n* = 998)
Never	1	1	1
About once a month to once/twice a year	1.0 (0.9–1.2)	1.1 (0.9–1.3)	1.0 (0.6–1.6)
Couple of times a month to once a week	1.1 (0.9–1.3)	1.1 (0.9–1.3)	1.2 (0.8–2.0)
2–3 times a week	**1.4 (1.1–1.8)**	1.3 (0.9–1.8)	1.5 (0.8–2.8)
4–7 times a week	1.2 (0.5–2.9)	1.8 (0.9–3.9)	**0.3 (0.1–0.5)**
Frequency of spirits intake during the last 12 months[e]	(*n* = 2402)	(*n* = 1404)	(*n* = 998)
Never	1	1	1
About once a month to once/twice a year	1.1 (0.9–1.3)	**1.3 (1.0–1.7)**	**0.8 (0.6–1.0)**
Couple of times a month to once a week	0.9 (0.8–1.1)	1.2 (0.9–1.6)	**0.6 (0.4–0.8)**
2–3 times a week	1.2 (0.9–1.7)	**1.6 (1.0–2.3)**	0.8 (0.4–1.3)
4–7 times a week	1.2 (0.5–2.9)	1.8 (0.9–3.9)	**0.3 (0.1–0.5)**
Frequency of beer/cider/long drinks intake during the last 12 months[f]	(*n* = 2402)	(*n* = 1404)	(*n* = 998)
Never	1	1	1
About once a month to once/twice a year	1.1 (0.8–1.3)	0.9 (0.7–1.3)	**1.4 (1.0–2.0)**
Couple of times a month to once a week	1.0 (0.8–1.2)	0.9 (0.6–1.2)	1.3 (0.9–1.9)
2–3 times a week	1.0 (0.8–1.3)	1.0 (0.7–1.3)	1.3 (0.9–2.0)
4–7 times a week	0.9 (0.6–1.3)	0.8 (0.5–1.2)	1.3 (0.8–2.2)

Adjusted relative risk (RR) with 95% confidence interval (95% CI).
Model 1: Adjusted for age, gender, education, Body mass index (continuous), the use of non-steroidal anti-inflammatory drugs, and the use of lipid-lowering drugs, the presence of plaque, dental attendance pattern, toothbrushing frequency, C - reactive protein (continuous) and log form of number of teeth as offset variable.
[a]Adjusted for Model 1 + the average spirit intake and the average intake of beer/cider/long drinks (continuous).
[b]Adjusted for Model 1 + the average wine intake and the average intake of beer/cider/long drinks (continuous).
[c]Adjusted for Model 1 + the average wine intake and the average spirit intake.
[d]Adjusted for Model 1 + the intake frequency of spirits and beer/cider/long drinks.
[e]Adjusted for Model 1 + the intake frequency of wine and beer/cider/long drinks.
[f]Adjusted for Model 1 + the intake frequency of wine and spirits.
Statistically significant values ($p < .05$) are in bold.

are in many cases more attributable to healthy lifestyle and good health behaviour of the wine drinkers than the possible biological beneficial effect of wine itself. This interpretation concurs with those studies where wine drinking has been reported to be associated with higher social status than beer drinking [15] and wine drinkers have been reported to have better dietary habits and a healthier lifestyle than those who consumed spirits or beer [30].

SEP relatedness suggests that the inability to thoroughly control for confounding using multivariate methods can be due to unknown or unmeasured covariates. To our knowledge, no previous studies have investigated the effect of different alcoholic beverages with periodontal health outcomes within different SEP. One effective method to control for SEP-related confounding is to restrict to one SEP stratum. In a study by Pitiphat et al. [6], participants consisted of one fairly homogenous socioeconomic stratum, male health professionals. It is noteworthy that this study reported no clear association of any alcoholic beverages with periodontitis risk.

An additional reason for inconsistent findings between educational groups could also be the combined or simultaneous use of different types of alcoholic beverages.

This biasing effect is possible despite the fact that we adjusted for the use of other alcoholic beverages. Besides these above-mentioned aspects, the variation in outcome, exposure and confounding variables could also explain the conflicting findings between the present and some of the previous studies. Lastly, the conflicting results between studies may also be related to genetic factors. For instance, these genetic factors can be related to differences in alcohol sensitivity attributed to aldehyde dehydrogenase genotypes [31,32].

Concluding remarks

The result of this study, that the association of different alcoholic beverages with periodontal condition appears to be dependent on SEP or related factors, suggests that many of the earlier studies may be confounded by SEP. This means that from a research point of view it is important that the effect of SEP is adequately controlled for, either thoroughly through stratification methods or by using a homogenous study population. The subsequent pertinent question then – in case the results are distinct between socioeconomic strata, as they are in this study – is determining which stratum of SEP provides the most accurate results.

In this study, we used not only the amount and the frequency of alcohol use as exposure variables, but alcohol use was measured using a clinical measure, GGT. The amount and frequency appeared to behave differently, and when compared to GGT, it was found that the frequency variable diverges more from GGT than the amount variable. A possible reason for this could be related to behavioural aspects of alcohol use. Based on these observations, it can be concluded that the amount variable is a somewhat less confounded variable and more closely related to biological effects of alcohol use than the frequency variable.

No strong or consistent associations between the types of alcoholic beverages and the presence of teeth with deepened ($\geq$4 mm) periodontal pockets was found. The association of different alcoholic beverages with periodontal condition appears to be dependent on SEP or related factors. Possible biological effects, if any, of different alcoholic beverages remains to be confirmed in future studies.

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Disclosure statement

The authors declare no conflicts of interests and have nothing to disclose in this study.

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