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Association of smoking and snuffing with dental caries occurrence in a young male population in Finland: A cross-sectional study

TARJA TANNER[1], ANTTI KÄMPPI[1], JARI PÄKKILÄ[2], MARJO-RIITTA JÄRVELIN[3,4,5,6,7], PERTTI PATINEN[8], LEO TJÄDERHANE[1,9,10], & VUOKKO ANTTONEN[1,10]

[1]*Institute of Dentistry,* [2]*Department of Mathematical Sciences, University of Oulu, Finland,* [3]*Imperial College, London, UK,* [4]*Institute of Health Sciences, University of Oulu, Finland,* [5]*Department of Children, Young People and Families, National Institute for Health and Welfare, Finland,* [6]*Biocenter Oulu, University of Oulu, Finland,* [7]*Unit of Primary Care, Oulu University Hospital, Oulu, Finland,* [8]*Centre for Military Medicine, Finnish Defence Forces, Lahti, Finland,* [9]*Medical Research Center Oulu, Oulu University Hospital and University of Oulu, Finland, and* [10]*University Hospital, Oulu, Finland*

Abstract

Objective. The aim of this study was to investigate the prevalence of smoking and snuffing habits in association with dental caries occurrence in a male cohort born in the early 1990s in Finland. The impact of health behaviours and factors related to the place of residence were included in analyses. ***Materials and methods.*** Oral health of 8537 conscripts was screened in a cross-sectional study. In the same occasion they also answered a questionnaire covering their smoking and snuffing habits and other background factors. The residence-related factors were obtained from the Defence Forces' database. Cross-tabulation together with chi-squared test and generalized linear mixed models were used for analyses. ***Results.*** Almost forty per cent (39.4%) of the men reported smoking daily and 9.0% reported daily snuffing. Restorative treatment need of those who reported frequent smoking was more than 2-fold (mean DT = 2.22) compared to the non-smokers (mean DT = 1.07). Smoking was statistically significantly associated with other harmful health behaviours. The snuffers reported more snacking than the non-smokers, but were most frequent brushers. The result from the statistical modelling showed that smoking, low tooth brushing frequency, eating sweets and consuming energy drinks frequently were significantly associated with restorative treatment need. ***Conclusion.*** In this cross-sectional study, association between smoking and dental caries was distinct. The high rate of restorative treatment need among smokers may be explained by their poor health behaviours. Dietary habits of the snuffers seem harmful too, but are compensated by good tooth brushing frequency.

Key Words: *dental caries, smoking, snuffing, young adults*

Introduction

Smoking is a worldwide problem causing fatal diseases of nearly 6 million people every year and economic burden of hundreds of billions of dollars [1]. In Europe, 32% of the population (men and women) are smokers, which is more than the respective figures in Western Pacific (28%), Americas (21%), Easter Mediterranean (19%), South-East Asia (18%) and Africa (10%) [1] show. Smokeless tobacco is also used worldwide and the products vary considerably. In South-East Asia and part of Africa, smokeless tobacco is often chewing tobacco combined with for example areca or betel nuts. In the US, chewing tobacco and dry or moist snuff are often used. The most common smokeless tobacco product in Europe is moist snuff used on oral mucosa, usually in the sulcus under the upper lip called *snus* (Sweden) [2].

Using tobacco products in the adolescent population aged 12–18 years has been monitored in Finland every 2 years since 1977. According to those reports, the prevalence of smoking has decreased, whereas that of snuffing has increased in all age groups during the past three decades [3]. The same phenomenon has been reported also among a young male population in

Correspondence: Tarja Tanner, Institute of Dentistry, University of Oulu, PO Box 5281, FI-90014, Finland. Tel: +35840 417 8501. Fax: +08 5375560. E-mail: tarjatanner@hotmail.com

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Finland [4]. According to the Adolescent Health and Lifestyle Survey in 2011, 25.4% of the 18-year-old boys were daily smokers and 14.4% used snuff occasionally or every day. The respective figures for the girls were 23.0% and 2.7% [3]. Import and marketing of snuff have been banned within the entire European Union (EU) region since 1992.

The influence of smoking on general health, including oral health, is well known [5,6]. There are some studies also showing an association between dental caries and smoking habits [7,8]. On the other hand there are also studies in which that association is unclear or even missing [9,10]. The association between smoking on dental caries has been explained by, i.e., poor oral hygiene and harmful dietary habits associated with a smoking habit [11–13]. Smoking [14] and dental caries both are associated with socioeconomic factors [10,15–18]. There are fewer studies on the association of smokeless tobacco, e.g. snuff use, and oral health.

In Finland, military service is obligatory for men under 28 years of age unless they have a physical or mental disability preventing the military service [19]. The service voluntary is for women of the same age. The draftees usually enter the military service between 18–20 years. This is only a couple of years after their legal right to dental care free of charge, which ends at the age of 18 years [20].

The main aim of this cross-sectional study was to investigate the prevalence of smoking and snuffing habits among the male population born in the early 1990s in Finland and their association with dental caries occurrence. The association of smoking and snuffing with oral health behaviours and factors related to the place of residence were also investigated. The aim was to find harmful behavioural patterns, which information could be used for health promotion.

The hypothesis was the prevalence of dental caries was higher among the smokers and snuffers than among the non-smokers and non-snuffers. It was also hypothesized that smoking and snuffing habits were associated with other harmful oral health behaviours. Oral health behaviours were hypothesized to have stronger association with caries occurrence compared to smoking, snuffing and geographical factors.

Materials and methods

This study is a part of the project 'Oral health of the conscripts 2011'. The original cross-sectional study was designed in the spring of 2010 and carried out in 20 garrison health centres (of a total 24) of the Finnish Defence Forces in January and July 2011. The protocol, criteria and calibration have been described in detail in earlier articles on the project [21] and data [18,22].

The screening of oral health of the conscripts was carried out as a part of the obligatory general health inspection during the conscripts' first week in the military service in 2011. All draftees in all but five biggest garrisons were examined. In the five biggest ones the participants were selected randomly (every 5^{th} in alphabetical order). All the dentists working in the Defence Forces, a dentist conscript doing his military service and two external researchers (AK and TT, both DDS) (n = 15) carried out the oral health screenings. A study group comprised 8685 conscripts born in 1990, 1991 or 1992 (mean age 19.6 years); of them 8537 were males and 148 females. Their caries status was screened using the WHO criteria for epidemiological dental caries studies [23] and using the Defence Forces' protocol in registering treatment need. Because the proportion of the female conscripts was very small among the study group, their data were excluded from the study population.

DT, DMFT

DMTF and DT values were used as the response variables in analyses. For statistical modelling, the DT and DMFT values were dichotomised as follows; DT >0 and rest and DMFT >1 and rest.

Questionnaire

In connection with the oral screening, conscripts had an opportunity to answer a computer-based questionnaire developed in the University of Oulu, Institute of Dentistry, Finland, for investigating individual background factors and health behaviours, i.e. dietary and oral hygiene habits [22]. Answering the questionnaire was voluntary, but no one refused. By answering it, the conscripts gave their consent to use their personal military and health records.

The responses to the following questions were used: *Do you smoke?* (not at all/1–5 cigarettes daily/ 10–20 cigarettes daily/ >20 cigarettes daily); *Do you use snuff?* (never or hardly ever/every day or almost every day/occasionally); *What is your education?* (comprehensive school/vocational school/university of applied sciences/vocational school and matriculation exam or upper secondary school/matriculation exam or upper secondary school/college or university/ other); *How often do you eat/drink the following snacks: sweets/crisps/soft drinks/energy drinks?* (never or hardly ever/every day or almost every day/occasionally during the week); and *How often do you brush your teeth?* (never or hardly ever/occasionally/every day). For those persons who reported brushing their teeth every day, a new question opened up: *How many times a day do you brush your teeth?* (once a day/twice a day/more than two times a day).

Factors associated with the place of residence

The following variables associated with the place of residence were also used as confounding variables in analyses: province, urban–rural, language in home municipalities (Finnish only, mainly Finnish and combining mainly Swedish/Swedish only) and fluoride content in drinking water (0.0–0.3 mg/l, >0.3–0.8 mg/l, >0.8 mg/l) [18].

Statistical issues

For statistical analyses, the responses to the questions on smoking and using snuff were dichotomized as follows: those smoking 1–5 cigarettes daily or more and the rest and those using snuff at least occasionally during the week and the rest. A new variable was created to allow analysing persons according to their smoking and snuffing habits (no smoking/no snuffing, smoking/no snuffing, no smoking/snuffing and smoking/snuffing).

The confounding variables were dichotomized as follows: those eating/drinking snacks at least occasionally during the week and the rest. The two questions dealing with tooth brushing were combined and categorized in three groups as follows: those brushing teeth two times or more daily, those brushing teeth daily and the rest. The education level was categorized in three groups: vocational school, matriculation exam or upper secondary school and the rest.

Cross-tabulation was used to analyse the association between smoking/using snuff and other health behaviours and the education level. The significance between the groups was tested by chi-squared tests. Mean DT and DMFT values were investigated in four categories and the differences between the groups were analysed with the one-way ANOVA. Statistical significance was determined at $p < 0.05$. For analysing the risks (OR, 95% CI) for occurrence of dental caries (bivariate responses DT = 0 or DT >0 and DMFT ≤1 or DMFT >1) generalized linear mixed models with logit link function were conducted [24]. In these models, the garrison was treated as a random effect. The initial models included all independent variables and first-order interactions between health behaviours and smoking/snuffing. Interaction terms did not reach statistical significance ($p < 0.05$) and were eliminated from the final models. Frequency of smoking and snuffing in different parts of the country was demonstrated as graphics. All analyses were executed and figures drawn using the SPSS software (versions 16.0 and 18.0, SPSS, Inc., Chicago, IL) and R software (version 2.15.1 Patched. A language and environment for statistical computing; R Foundation for Statistical Computing, Vienna, Austria, URL; http://www.R-project.org).

Ethical issues

The data were collected from the archives of the records of the Finnish Defence Forces with their permission. For identification, ID numbers were created for all conscripts. The key for the IDs and the patient records are kept in the archives of the Defence Forces. The conscripts gave their consent to use their patient records by answering the voluntary computer-assisted questionnaire. With respect to ethics, the main research plan was evaluated by the Ethical Committee of the Northern Ostrobothnia Hospital District and positive consent was given on 30 March 2010. The Centre for Military Medicine of the Finnish Defence Forces gave its permission for the study in June 2010 (AG14218/23.6.2010).

Results

Almost four in 10 (39.4%; $n = 3361$) reported daily smoking and 9.0% ($n = 768$) daily snuff use (Table I). In the study population, 28.8% reported only smoking, 8.6% reported only snuff use and 10.5% reported dual use (Table II). The frequency of smoking and snuffing in different parts of the country is illustrated in Figure 1. Smoking was significantly (OR = 2.06; 95% CI = 1.82, 2.33) associated with snuffing and so was snuffing with smoking (OR = 2.04, 95% CI = 1.82, 2.30).

Table II presents mean DMFT and DT values, eating behaviours of unhealthy snacks, tooth brushing frequencies and education level in four categories in association with the use of tobacco products. Restorative treatment need of those who reported frequent

Table I. Prevalence of smoking and snuffing and number of cigarettes smoked or snuff used among 20 year old conscripts (mean age = 19.6 year).

Smoking (cigarettes/day), % (*n*)				
None	1–5	10–20	>20	Total
60.6 (5176)	12.8 (1093)	24.0 (2048)	2.6 (220)	100 (8537)
Using snuff, % (*n*)				
Never or hardly ever	Occasionally during the week	Every day or almost every day	Total	
81.0 (6912)	10.0 (857)	9.0 (768)	100 (8537)	

Table II. Mean DT and DMFT values, prevalence of eating behaviours of unhealthy snacks (crisps, soft drinks, energy drinks), tooth brushing frequencies and education levels in four categories according to the use of tobacco products; n = 8537 mean age = 19.6 years.

Associated variables	No smoking & no snuffing n = 4445 (52.1%)	Smoking & no snuffing n = 2467 (28.9%)	No smoking & snuffing n = 731 (8.6%)	Smoking & snuffing n = 894 (10.5%)	p-value
Eating sweets at least occasionally during the week (%) (73% of conscripts)	75.7	70.7	69.6	72.9	< 0.001
Eating crisps at least occasionally during the week (%) (59.4% of conscripts)	55.6	64.6	57.2	65.5	< 0.001
Drinking soft drinks at least occasionally during the week (%) (86.9% of conscripts)	83.4	91.6	86.7	91.9	< 0.001
Drinking energy drinks at least occasionally during the week (%) (51.6% of conscripts)	39.2	64.5	60.7	70.5	< 0.001
Brushing teeth (%)					< 0.001
At least two times daily (52.8% conscripts)	55.9	43.5	65.1	53.0	
daily (36.7% of conscripts)	35.5	41.1	28.2	37.4	
Less frequently than daily (10.5% conscripts)	8.6	15.4	6.7	9.6	
Education (%)					< 0.001
Vocational school (44.0% of conscripts)	35.1	59.5	38.6	50.3	
Matriculation exam or upper secondary school (41.0% of conscripts)	55.1	18.5	48.0	26.8	
Other (15.0% of conscripts)	9.8	21.9	13.4	22.8	
Mean DT (SD)	1.07 (2.05)	2.23 (3.29)	1.03 (1.67)	1.94 (2.89)	< 0.001
Mean DMFT (SD)	3.55 (3.78)	5.43 (4.85)	3.79 (3.59)	4.98 (4.40)	< 0.001

smoking was more than 2-fold compared to the non-smokers (Table II). Smoking was also statistically significantly associated with other harmful health behaviours (snacking habits, poor oral hygiene). Snacking (apart from sweets) was also more common among snuffers than non-smokers. Fifty-six per cent of the study population brushed their teeth twice a day or more frequently. The non-smokers were more frequent tooth brushers than the smokers or dual-users. However, the snuffers brushed their teeth most frequently of all (Table II). For the smokers and dual-users, the education level was more often lower, i.e. vocational school than for the snuffers and non-smokers, whose education level was most often upper secondary school (Table II).

The result from the generalized linear mixed models showed that the odds ratios were almost similar for both models, having DT >0 and DMFT >1 (Table III) as binary outcome variables. Smoking was distinctly associated with DT and DMFT values,

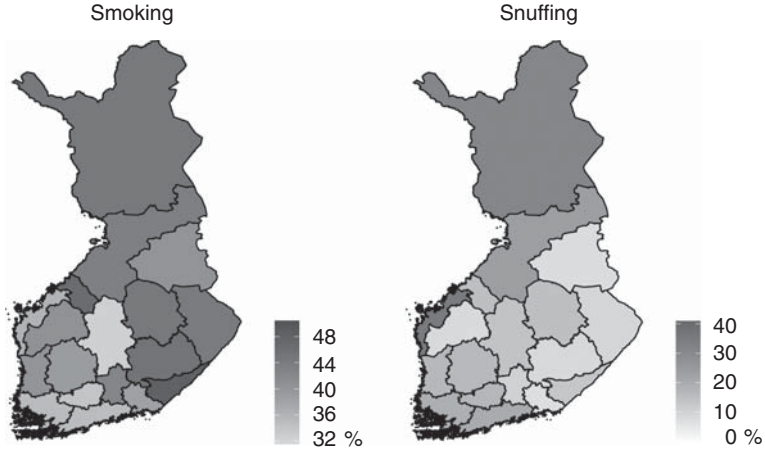

Figure 1. Smoking (1–5 or more cigarettes daily) and snuff use (at least occasionally during the week) among the young adolescents in different provinces in Finland.

Table III. Odds ratios and 95% confidence intervals (CI) from generalzed linear mixed models having restorative treatment need and history (DT >0 and DMFT >1) as response variables.

	DT >0 (n = 3914)		DMFT >1 (n = 5583)	
Explanatory factor	OR	95% CI	OR	95% CI
Smoking	1.58	1.43, 1.75	1.39	1.25, 1.55
Snuffing	1.04	0.92 1.17	1.12	0.98, 1.28
Sweets	1.18	1.06, 1.32	1.27	1.14, 1.42
Soft drinks	1.16	1.00, 1.34	1.21	1.04, 1.40
Crisps	0.97	0.88, 1.08	0.97	0.87, 1.07
Energy drinks	1.15	1.04, 1.27	1.17	1.05, 1.29
Living in rural area	1.15	1.02, 1.30	1.10	0.97, 1.26
Toothbrushing				
Two times daily or more	1		1	
Daily	1.20	1.09, 1.33	1.03	0.93, 1.14
Less frequently than daily	2.16	1.84, 2.54	1.63	1.36, 1.95
Education				
Vocational school	1		1	
Matriculation exam or upper secondary school	0.59	0.53, 0.66	0.56	0.50, 0.63
Other	1.21	1.05, 1.39	0.97	0.84, 1.13
Fluoride in drinking water				
0–0.3 mg/l	1		1	
>0.3–0.8 mg/l	0.92	0.78, 1.09	1.09	0.92, 1.29
>0.8 mg/l	0.77	0.61, 0.96	1.19	0.94, 1.51
Language				
Finnish only	1		1	
Mainly Finnish	1.11	0.88, 1.40	1.01	0.80, 1.27
Mainly Swedish or Swedish only	1.02	0.66, 1.57	1.02	0.66, 1.58
Province				
Varsinais-Suomi	1		1	
South Karelia	0.77	0.44, 1.34	0.82	0.50, 1.36
Etelä-Savo	1.55	0.94, 2.54	1.42	0.92, 2.18
North Ostrobothnia	2.07	1.35, 3.17	1.51	1.10, 2.06
Päijät-Häme	1.04	0.68, 1.59	0.96	0.67, 1.39
Pohjois-Savo	1.22	0.80, 1.88	1.44	0.99, 2.08
Central Ostrobothnia	1.83	0.99, 3.38	1.56	0.84, 2.89
Kainuu	1.30	0.71, 2.38	1.49	0.83, 2.69
North Karelia	1.34	0.82, 2.19	1.08	0.73, 1.58
Kymenlaakso	1.13	0.65, 1.96	0.48	0.29, 0.77
South Ostrobothnia	1.25	0.87, 1.79	1.31	0.94, 1.83
Uusimaa	1.49	1.11, 1.99	0.89	0.70, 1.13
Lapland	1.31	0.83, 2.05	1.20	0.86, 1.67
Pirkanmaa	1.06	0.77, 1.46	1.00	0.75, 1.33
Kanta-Häme	1.24	0.81, 1.91	1.07	0.73, 1.59
Central Finland	1.59	1.09, 2.31	1.09	0.80, 1.50
Satakunta	1.29	0.91, 1.82	1.46	1.04, 2.05
Ostrobothnia	0.99	0.63, 1.56	1.64	1.03, 2.62

whereas using snuff was only associated with high DMFT values. Low tooth brushing frequency (less than daily) had the biggest odds for caries occurrence. Also, frequent eating of sweets and consuming energy drinks were significantly associated with both restorative treatment need and DMFT values. Living in a rural area was slightly associated with the risk for high DT values. Living in an area where the fluoride level in drinking water was high (>0.3 mg/l) as well as high education status were protective factor for dental caries. ORs for restorative treatment need (DT) and DMFT varied in provinces—both being significantly elevated in North Ostrobothnia. No joined effects of risk factors on restorative treatment need and DMFT could be detected.

Discussion

The main finding of this study is that restorative treatment need among the smokers is higher, even 2-fold, compared to the non-smokers. Dental caries prevalence of the dual-users' is almost as poor as that of the smokers, whereas caries occurrence of the snuffers and the non-users is almost the same. Smoking seems to attract other harmful oral health behaviours like snacking and infrequent tooth brushing. Snuff use is also associated with snacking, but also with the most frequent tooth brushing compared to others.

Our results are contradictory with those by Hugoson et al. [10], who proposed that there are no statistically significant differences in restorative treatment need between the snuff users, smokers and non-users in 2003. In previous decades (1983 and 1993) similar findings to ours were seen in their cross-sectional studies; dental caries experiences being significantly lower among snuffers than among other groups. Neither are these results in accord with a study from India where caries occurrence was the highest among the tobacco chewers followed by regular smokers and ex-smokers [25]. It is good to keep in mind that smokeless tobacco products differ from one side of the world to another, which means that the results are not directly comparable. In the present study and in the study by Hugoson et al. [10], snuff made in Sweden was used. Also the sizes of study populations vary; in this study the study population is considerably bigger than in the studies by Hugoson et al. [10] and Vellappally [25]. The study groups aren't directly comparable as to the age of the participants, either. It can be speculated if different background factors, health behaviours and cultural differences also cause variation in results. Further investigations are needed; multi-centre studies on the topic would be valuable. According to a longitudinal study from Sweden [26], tobacco-use (both cigarette smoking and snuff use) was associated with increased caries prevalence during adolescence, irrespective of socio-economic and geographic factors. Factors concerning health behaviours were not included in analyses by Holmen et al. [26].

It was our hypothesis that smoking and snuffing habits are associated with other harmful oral health behaviours, such as low tooth brushing frequency and frequent use of soft and energy drinks and sweets. The findings in this study are in accord with previous studies where non-smokers brushed their teeth more frequently than smokers [13,27] and their snacking habits were also healthier [11]. Here, snacking, apart from sweets, was more common among the snuffers than the non-smokers. Our findings are in accord with the study by Engström et al. [14], where the dietary habits of the snuffers were reported to be more harmful than those of the non-users (less fruits and vegetables and more alcohol).

An interesting finding in this study is the good oral health situation of the snuffers. Their low restorative treatment need may be explained by their more favourable brushing habits compared to the rest. Hugoson et al. [10] propose that salivary buffer capacity of the snuffers is higher compared to the non-users, which may favour remineralization of caries lesions and promote inhibition of the cariogenic microflora. The effect of snuff on oral mucosa was not studied here. This topic needs further investigation.

Earlier, we have reported how the place of residence influences caries occurrence [18]. This study offers a more profound aspect on the issue. The importance of sociodemographic factors remains, but the affect is decreased when health behaviours are included in the analyses. According to the present study, oral health behaviours, but also residence-related (e.g. fluoride in the drinking water) and socioeconomic factors (e.g. educational level) are all significantly associated with caries occurrence.

Snuffing seems to be more common in the provinces near to the western borders of the country and in urban areas, maybe due to the easier access to the snuff products. The study by Huhtala et al. [28] reports that the total ban for selling snuff in 1995 in Finland did not end snuff use; on the contrary, the increase in use continued after it. It is legal to import snuff for personal use; usually from Sweden. Use of snuff products has increased during the past three decades and the same trend continues according to our results. Maybe one reason for that is that snuff use is perceived as less harmful than smoking [29] and is, thus, well accepted and also a more modern form of tobacco than cigarettes. This is true especially in areas where it is easily available. In addition, negative health effects of snuff are poorly known, which may increase its' use particularly among physically active persons [4].

Among the present study population the educational level of 85% of the subjects was vocational school or matriculation exam or upper secondary school; therefore the focus in the analyses was on them. The

high educational level of the conscripts is a significant protective factor both for restorative treatment need and for smoking. These findings are in line with many previous studies [14–17]. The educational background among the snuffers varies. Engström et al. [14] discovered that low educational background is significantly more common among the smokers than the snuffers, which is in line with our findings.

Social determinants associated with smoking were not investigated in this study. The influence of friends is important also in smoking cessation. According to the study by Heikkinen et al. [30], those whose best friend was a non-smoker were 7-times more likely to stop smoking compared to the others. In this study oral health screening and answering the questionnaire took place during the first 2 weeks in military service when the military service has not yet influenced conscripts' behaviours. It would be interesting to investigate how smoking and snuffing habits will change during military service. That could be the theme of another study.

A great advantage of the present study is its large study population (8537), born in the early 1990s in Finland. Studies, like the present one, on this age group are hard to find. The value of this study is the information provided, combining the outcomes of screening (made by calibrated dentists) and the questionnaire. A shortcoming of this study is it's lack of data on the history and social determinants associated with use of tobacco products. This study is also cross-sectional, therefore offering only a snapshot of the study group's lifestyle and oral health situation. In evaluating correlations, longitudinal studies on the topic would be necessary, also considering the general health risks caused by smoking and health behaviours associated with cultural factors.

Conclusion

According to this study, smoking also attracts other unhealthy behaviours, increasing it's harmfulness. Smokers have more present restorative treatment need as well as earlier treatment history compared with the non-smokers and snuffers. On the other hand, dietary habits of the snuffers seem harmful, but are compensated by good tooth brushing frequency. The place of residence increases the odds for using snuff in Finland, most likely because of the easier access to snuff products near the Swedish border. Health behaviours including smoking as well as factors associated with the place of residence are associated with caries occurrence, which should be considered in oral health promotion.

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