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Dental caries is associated with lower respiratory tract infections: a population-based cohort study

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Abstract

Introduction

Dental caries and respiratory tract infections are among the most common infectious diseases worldwide and they both are appearing in the respiratory system. However, their relations are still unclear. This study investigated the association of dental caries on the risk of lower respiratory tract infections (LRTI) in young adulthood.

Methods

The study population consisted of 1,592 Finnish young adults participating in the 20-year follow-up of The Espoo Cohort Study. The information on the occurrence of LRTIs (pneumonia or acute bronchitis) during the preceding 12 months was based on the follow-up questionnaire and the National Hospital Discharge Register. Lifelong caries on permanent teeth was defined as a self-reported number of filled teeth (FT). The risk ratios (RR) of LRTIs with 95% confidence intervals (CI) were estimated using Poisson regression models.

Results

High FT number was associated with an increased occurrence of LRTIs with an adjusted RR of 1.24 per interquartile range (IQR) of FT (95% CI 1.06-1.44). The risk of LRTIs increased according to the increasing number of FTs, being highest among those subjects with 10 or more filled teeth (adjusted RR 2.30; 1.27-4.17). Family's socioeconomic status or smoking did not modify the effect.

Conclusions

Our results suggest that dental caries increases the risk of LRTIs. We did not find any significant effect modification by shared determinants of caries and LRTIs. However, it is possible, that common risk factors might explain at least partly the observed relation between FT and LRTIs or that the causality is bidirectional.

Keywords: filled teeth; dental caries; respiratory tract infections; lower respiratory tract infections; cohort studies

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1. Introduction

Dental caries and respiratory tract infections are among the most common infectious diseases worldwide. Dental caries is an infectious disease affecting the majority of adults and 60-90 % of schoolchildren, making it one of the most prevalent chronic diseases globally [1]. Lower respiratory tract infections (LRTIs) are also common. According to the Global Burden of Diseases, Injuries, and Risk Factors (GBD) Study from 2016, there were 45.5 LRTI episodes per 1000 people in year 2016 [2]. Although they both appear in the respiratory system, caries at the beginning of it at the mouth and lower respiratory infections deeper in the respiratory tract, their relations are still unclear.

There is some evidence suggesting that the occurrence of middle ear and respiratory tract infections during the early childhood may have a role in development of childhood caries [3] and/or development defects of enamel in permanent teeth [4], which exposes defected surfaces to caries [5, 6]. In our previous article, we reported that the occurrence of LRTIs in the early childhood predicted the development of dental caries in the 20-year prospective population-based Espoo Cohort Study [7]. However, the underlying mechanisms in the causation are not clear. Based on our systematic literature search, there are no previous studies addressing the effect of dental caries on the risk of respiratory infections. Therefore, our objective was to investigate the effect of dental caries, defined as the number of filled teeth (FT), on the risk of LRTIs in young adulthood in the Espoo Cohort Study. We elaborated the causal hypothesis that caries measured as FT increases the risk of LRTIs even when adjusting for some of the shared determinants of caries and LRTIs.

2. Materials and methods

2.1. Study population

The source population of our study included all the children born in the city of Espoo, the second largest city in Finland that is located in southern Finland, between January 1, 1984 and March 31, 1990. A random sample was drawn from the roster of Statistics Finland and a questionnaire was sent to their parents. The baseline population included 2,568 children whose parents answered the questionnaire (response rate = 80.3 %) in 1991 [8]. In year 1997, we conducted a 6-year follow-up survey of the cohort, with a follow-up rate of 77.3 % [9-10]. We conducted a 20-year follow-up study in years 2010-2011 with 1,623 participants (response rate = 63.2 % of the baseline study population) [7, 11]. The current study population consisted of 1,592

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participants including those with all the information on the exposure and outcome variables. The study protocol was approved by the Ethics Committee of Oulu University Hospital (Oulu, Finland).

2.2. Health outcome

The outcome of interest was the occurrence of at least one LRTI during the preceding 12 months, when the study subjects were from 20 to 27 years of age. We retrieved the information from a 20-year follow-up questionnaire and from the National Hospital Discharge Register, where all the visits to public hospitals and hospitalizations are registered. The information was retrieved from the register based on ICD-10 codes. The codes of interest were J10-J18 (influenza and different types of pneumonias) and J20-J22 (bronchitis, bronchiolitis and unspecified lower respiratory tract infection). The information on self-reported LRTIs was gathered on the questionnaire by asking: "How often were you having these diseases during the last year (12 months)?" The diseases of interest were bronchitis and pneumonia among other infectious diseases that were not observed in this particular study. The total number of study subjects who had had at least one LRTI episode was 132 of which 131 answered in the 20-year questionnaire that they had had at least one pneumonia or bronchitis. Altogether three persons had a LRTI episode according to the register data of which one did not provide the information on the questionnaire.

2.3. Determinant of interest

Caries was the determinant of interest. We gathered the information on the number of FT values in the 20-year follow-up questionnaire by asking: "Estimate, how many teeth with a filling you have?" This represents a cumulative number of FT appearing in permanent dentition until 20 to 27 years of age.

2.4. Covariates

We obtained information on age, sex and family socioeconomic status (SES) from the baseline questionnaire, information on early LRTIs from both the baseline questionnaire and the National Hospital Discharge Register [7], and information on smoking (categorized as being non-smoker, ex-smoker or current smoker) from the 20-year follow-up questionnaire. We categorized family SES as high if either parent had an academic degree and both parents were white-collar workers (e.g. governing, planning or consultation work) or entrepreneurs, and as low in any other

combination, such as if either parent did not have a degree, was a student or had a vocational degree but was unemployed, retiree or a blue-collar worker (e.g. factory, mine or construction work or agricultural work).

2.5. Statistical analyses

We estimated the association between number of FT and occurrence of LRTIs, while applying both continuous number of FT with interquartile range (IQR) increase and categorical number of FT. Categorizing was based on the FT distribution among the study subjects (Figure 1). The FT groups were zero, 1 to 3 (median of FT number), 4 to 9, and 10 or more (5 % of population) filled teeth. We used Poisson regression to estimate risk ratios (RR) and 95% confidence intervals (CI) for LRTIs. We fitted multivariable regression models to adjust for potential confounding and conducted stratified analyses according to family SES, smoking and early LRTIs to elaborate potential effect modification of the relation between FT and LRTIs. We conducted the analyses with SAS version 9.4.

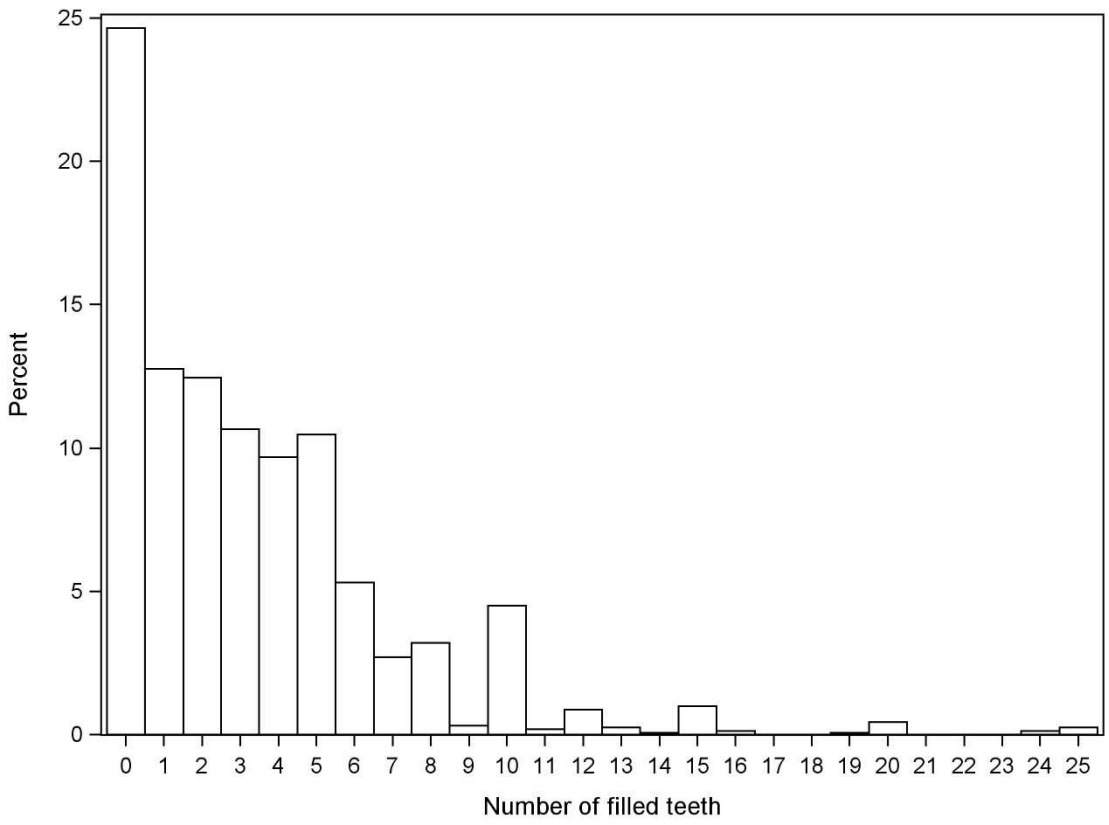

Figure 1. Distribution of filled teeth**.**

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3. Results

The median number of FTs was 3 (SD 3.63) and the IQR was 4 filled teeth (see Figure 1). Study subjects who had more than 3 filled teeth by the age of 20 to 27 years were older, more often men and smokers or ex-smokers and had lower family socioeconomic status compared to those who had 3 or less filled teeth (Table 1).

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Table 1. Characteristics of the Study Population, The Espoo Cohort Study.

	Number of filled teeth (FT)			Total
	≤ 3	> 3		
	n (%)	n (%)	p	n (%)
Total N	778 (48.87)	814 (51.13)	0.3669	1592 (100)
Age (years)			< 0.0001	
20	70 (9.00)	75 (9.21)		145 (9.11)
21	164 (21.08)	113 (13.88)		277 (17.40)
22	144 (18.51)	126 (15.48)		270 (16.96)
23	116 (14.91)	124 (15.23)		240 (15.08)
24	118 (15.17)	133 (16.34)		251 (15.77)
25	119 (15.30)	142 (17.44)		261 (16.39)
26-27	47 (6.04)	101 (12.41)		148 (9.30)
Gender			0.0406	
Male	396 (50.90)	456 (56.02)		754 (46.46)
Female	382 (49.10)	358 (43.98)		869 (53.54)
Family SES			0.0188	
Low	327 (42.03)	394 (48.40)		721 (45.29)
High	448 (57.58)	417 (51.23)		865 (54.33)
Missing	0	6 (0.73)		6 (0.38)
Smoking			0.0496	
Current smoker	207 (26.61)	240 (29.48)		447 (28.08)
Ex-smoker	71 (9.15)	97 (11.92)		168 (10.55)
Never smoked	498 (64.18)	477 (58.60)		975 (61.24)
Missing	2 (0.26)	0		2 (0.13)

N, number; SES, socioeconomic status

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High FT number was associated with an increased risk of LRTIs (Table 2). The occurrence of LRTIs during past 12 months was associated significantly with the number of FT with a 24 % increase in the risk per IQR of FT (adjusted RR 1.24 per IQR; 95% CI 1.06-1.44). The risk of LRTIs increased according to the increasing number of FT, being highest among those subjects with 10 or more filled teeth (adjusted RR 2.30; 1.27-4.17) (Table 2). In the analyses stratified by family SES (low compared to high status), smoking status (current or ex-smoker compared to never smoked) and early LRTIs (no/yes), the effect estimate was almost similar in all strata (Table 3). In addition, interaction terms were not significant.

Table 2. Risk ratios of the occurrence of at least one lower respiratory tract infection (LRTI) within past 12 months in relation to the number of filled teeth (FT), The Espoo Cohort Study.

	LRTIs in young adulthood					
FT number	**No.**	**%**	**Crude RR**	**95% CI**	**Adjusted RR[1]**	**95% CI**
IQR (4)			1.25	1.07-1.45	1.24	1.06-1.44
Categorized FT number						
0	25/369	6.78	1		1	
1 to 3	43/582	7.39	1.09	0.67-1.79	1.04	0.63-1.73
4 to 9	43/514	8.37	1.23	0.75-2.02	1.20	0.72-1.98
10 or more	21/127	16.54	2.44	1.37-4.36	2.30	1.27-4.17

LRTI, lower respiratory tract infection; No, number; RR, risk ratio; CI, confidence interval; IQR, interquartile range

[1]Adjusted for gender, age, smoking status, family socioeconomic status and LRTIs at baseline

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Table 3. Risk ratios of the occurrence of at least one lower respiratory tract infection (LRTI) within past 12 months in relation to the number of filled teeth (FT) stratified for shared determinants, The Espoo Cohort Study.

	LRTIs in young adulthood			
FT number	**Adjusted RR**	**95% CI**	**Adjusted RR**	**95% CI**
	Low family SES (n=721)		**High family SES (n=865)**	
IQR (4)	1.24[a]	1.01-1.51	1.22[a]	0.96-1.54
	Non-smoker (n=975)		**Ex- or current smoker (n=615)**	
IQR (4)	1.20[b]	0.95-1.52	1.26[b]	1.03-1.55
	No early LRTIs (n=1281)		**LRTI (≥ 1) (n=311)**	
IQR (4)	1.22[c]	1.01-1.47	1.26[c]	0.96-1.64

LRTI, lower respiratory tract infection; FT, filled teeth; RR, risk ratio; CI, confidence interval; IQR, interquartile range

[a]Adjusted for gender, age, smoking status and LRTIs at baseline

[b]Adjusted for gender, age, family socioeconomic status and LRTIs at baseline

[c]Adjusted for gender, age, smoking status and family socioeconomic status

4. Discussion

The results in the 20-year examination of the prospective Espoo cohort study show that dental caries is associated with increased occurrence of LRTIs in young adults. An increase by four filled teeth was associated with 1.2-fold risk of LRTIs and persons with 10 or more filled teeth experienced even 2.3-fold risk of infections during the past 12 months compared to those with no fillings.

We tested a causal hypothesis that caries measured as FT increases the risk of LRTI. This hypothesis is supported by the strong association between FT and the risk of LRTIs. Further, causality is supported by evidence on temporality, i.e. the development of filled teeth usually took place years before the observed increase in the number of LRTIs and thus, caries is likely to precede LRTIs, which had occurred in the past 12 months prior to data collection. In addition, a dose-response relation observed between FT and LRTIs is consistent with causality. Increased risk of LRTIs in those with dental caries is also biologically plausible, as they both are infectious diseases appearing in the respiratory system. Several biomarkers, such as cytokines and other inflammatory mediators, are present in inflamed dental pulp (pulpitis), which is typically caused by oral

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microorganisms from dental caries [12, 13]. Chronic inflammation in the airways has been suggested to associate with impaired immunity leading to respiratory infections [14, 15].

However, there are some alternative explanations, which would refute the causal hypothesis. Dental caries and LRTIs may have one or several shared determinants, such as SES, smoking, life-style and health in general, which could confound the detected association. For example, there is consistent evidence that teeth with fillings are more common in lower SES class compared to higher status [16, 17]. The relation between family SES, smoking and FT in young adulthood was also present in the Espoo Cohort Study. We found that low family SES and current- or ex-smoking predicted higher FT number (see Table 1). They both are also determinants of the development of LRTIs. We conducted stratified analyses according to SES and smoking to elaborate potential effect modification of the relation between FT and LRTIs. In these analyses, we observed that the relation was similar across the strata. Nevertheless, we cannot rule out a possibility that shared determinants might at least partly explain the observed relation between FT and LRTIs. However, it is also possible that LRTI could cause caries. We have previously shown in the Espoo Cohort Study that the occurrence of LRTIs in the early childhood predicts the risk of FT in young adulthood [7]. Therefore, an increased susceptibility to respiratory infections might explain our findings in the current study or the causality may be bidirectional. Figure 2 illustrates the hypothesized causal diagram of the association between FT and LRTIs.

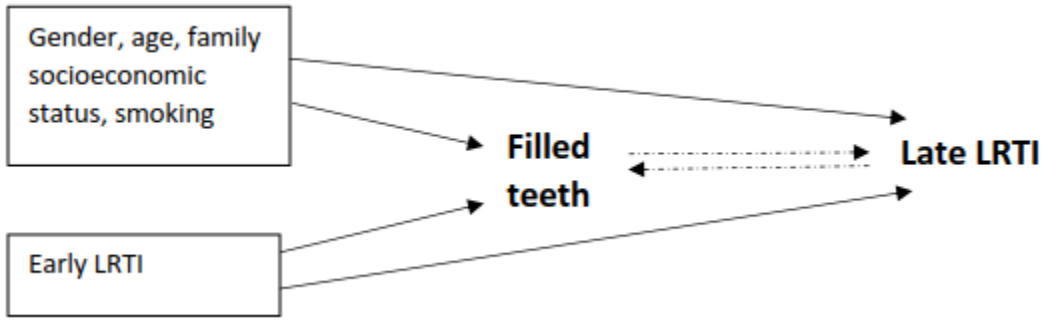

Figure 2. Hypothesized causal diagram of the association between filled teeth and LRTIs.

Information on number of FT was based on self-reporting rather than clinical examination, which could introduce either random or systematic error. There is, however, some evidence that self-reports of the number of dental fillings give reasonably valid information on the actual situation [18]. In addition, the self-reported FT frequencies in our study are remarkably similar with those

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reported by another study of young Finnish adults, whose oral health was screened by a dentist [19]. High availability and use of dental services in Finland give us a good reason to assume that the FT value used in this study as the predictor is a valid measure of former caries experience. Therefor we can also assume that detection of cavities and their treatment is not likely to be strongly associated with SES, i.e. study participants in low SES would be less prone to report correct number of FTs. We assumed that those study subjects who know they have many filled teeth, but do not know the exact number, may answer 10 filled teeth (FT distribution showed a peak at 10, see Figure 1).

Information on the frequency and type of LRTIs was mainly based on the follow-up questionnaire. Reporting in the questionnaire may have included some misclassification. However, the error is not likely to be systematic in relation to the number of FTs. In addition, we were able to retrieve an information from the National Hospital Discharge Register database, which has been consistently evaluated and shown to maintain highly complete and reliable data [20]. However, the register data included only severe infections, which lead to visits in special health care hospital units. Information on primary health care was not available at that time.

Because dental fillings of these study subjects were developing during the childhood and early adulthood, family socioeconomic status is a strong(er) determinant of FT and LRTI susceptibility than the current education of the young adults. In addition, most participants were students at the time of 20-year follow-up.

5. Conclusions

We present novel evidence that dental caries (described as the number of FT) increases the risk of LRTIs in young adulthood. Causal inference needs to be supported by further epidemiological studies with better measurements of caries prior to the experience of LRTIs. Better understanding of the plausible biological mechanisms will also strengthen the causal hypothesis that rises from our results.

Our findings have an important clinical relevance given the importance of dental caries and respiratory infections in public health worldwide. Prevention of caries in permanent teeth of children might also decrease the risk of LRTIs in the later years of life. In addition, physicians and dentists should inform people who have had a lot of caries of increased infection risk.

Declaration of interest

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None.

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- Dental caries increases the occurrence of lower respiratory tract infections
- This was observed both among subjects with low and high socio-economic status
- Ten filled teeth was related to a 2.3-fold risk for respiratory infections

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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