# STREPTOCOCCUS PNEUMONIAE CARRIAGE RATE IN HEALTHY PREADOLESCENT DENTAL PATIENTS

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### Abstract

*Introduction. Streptococcus pneumoniae is the major cause of death for pneumonia in the world, responsible 800,000 deaths annually among children and elderly. Most pneumonia caused by pneumococci are healthcare associated, while the remaining are community acquired. Airborne infections are frequent in dental healthcare settings, but data regarding the risk for pneumococci transmission are lacking.*

*Aim. To estimate S. pneumoniae carriage rate among adolescent dental patients, in order to investigate the risk for pneumococci acquisition and spread in dental healthcare settings.*

*Material and methods. 199 children aged 10-12 years attending the paediatric dentistry section of a dental hospital in Rome underwent oropharyngeal swab samples. Pneumococci were presumptively identified with cultural methods (growth on selective media, alpha haemolysis, bile solubility). Routine exposure to passive smoking, use of antibiotics, recent respiratory tract infections (RTIs) were anamnaestically investigated. Unadjusted and adjusted odds ratios (ORs) and individual probability to carry S. pneumoniae were assessed with logistic regression analysis.*

*Results. Overall S. pneumoniae carriage rate was 11.6% (95% confidence interval, 95CI, 7.2-16.0%). RTIs were significantly associated with carriage (adjusted OR, 3.3; 95CI, 1.3-8.7), exposure to passive smoking (OR, 2.0; 95CI, 0.8-4.9), male gender (OR, 3.2; 95CI, 0.6-17.1) were marginally associated (0.05<p<0.20). According to the regression model, male patients with recent RTI history and routinely exposed to passive smoking yielded 58.2% probability to carry pneumococci.*

*Conclusion. S. pneumoniae carriage rate in healthy preadolescent dental patients was moderately high. Patient's profile could be helpful to identify potential carriers and to adopt transmission-based precautions.*

*Key words: Streptococcus pneumoniae, healthcare-associated infections, dentistry, airborne infection, environment, infection control*

## Introduction

Streptococcus pneumoniae is a widespread colonizer of the upper respiratory tract, particularly in children younger than two years. Colonization of the human mucosa of the upper respiratory tract is determined by many factors, such as availability of resources (e.g., nutrients and space), defensive host factors, presence of toxins or harmful substances and type and number of established bacterial populations. For example, Haemophilus influenzae and Staphylococcus aureus, are other colonizers of the upper respiratory tract, which act in antagonism with S. pneumoniae colonization, while pre-existing pneumococci promote adhesion and colonization of other pneumococci strains[1]. S. pneumoniae is transmitted from person to person by respiratory droplets. Environmental factors responsible for transmission are indoor crowding, associated viral infections, lower humidity and air pollution[2]. In the majority of children these microorganisms are not responsible for disease (see, for example 3-5). However, in susceptible individuals, S. pneumoniae is responsible for mild infections, such as otitis media, sinusitis, conjunctivitis and even most serious diseases, such as pneumonia, meningitis, bacterial endocarditis[2]. The most famous example occurred during the deadly pandemic flu of 1918, when several millions of people from all over the world died by influenza-related pneu-

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monia. The majority of these deaths are now attributed to pneumococcal super-infection [6-7]. Today, S. pneumoniae is the major cause of death for pneumonia in the world, allegedly responsible for 826,000 deaths annually among children younger than five years, particularly those with important co-morbidities, such as HIV infection or malnutrition, and, only in US, for 401,000 hospitalizations in elderly aged 65 years or older, particularly smokers, alcohol drinkers, subjects with diabetes, chronic lung disease and immunodeficiency[8-9].

Pneumonia caused by pneumococci are associated with healthcare (HCAP, healthcare-associated pneumonia) or community acquired (CAP, community acquired pneumonia). HCAP definition is pneumonia developed in patients previously hospitalized in acute care hospitals for two or more days within ninety days of the infection, resided in a nursing home or long-term care facility, received recent intravenous antibiotic therapy, chemotherapy, or wound care within the past thirty days of the current infection, or attended a hospital or haemodialysis clinic[10]. S. pneumoniae is the most frequent etiological agent of HCAPs, being responsible for more than one fourth of all cases, while, for example, H. influenzae and S. aureus are responsible for one tenth and one fortieth, respectively. Thus, S. pneumoniae shares the same ecological niche, the same pattern of transmission and similar risk factors, antibiotic resistance, case-fatality rate as methicillin-resistant S. aureus (MRSA)[11].

Since infections caused by pneumococci are airborne, it would not be surprising that their transmission occurs during dental therapy. For example, oral fluid retraction, which occurs in >70% cases when the dental turbine stops rotating, is responsible for aspiration of oral strepto-cocci, non-pathogenic colonizers of the upper respiratory tract, in dental unit waterlines and subsequent spread in the environment during successive dental therapy[12]. The same pattern of transmission could be thought for pneumo-cocci. However, the risk of infection in dental healthcare settings cannot be based on mere conjectures, but must be founded on the solid basis of scientific evidence[13]. Indeed, while data regarding MRSA in dental healthcare settings are few, but sufficient to assess the risk for infection[14], persistence in the environment[15] and effect of different control measures[16], data

regarding S. pneumoniae in dental healthcare settings are lacking and do not allow to assess whether these microorganism pose any risk for infection or whether preventive guidelines are necessary. In absence of direct evidence of ascertained cases of infection transmission, indirect evidence could be drawn by observational studies[14].

## Aim

The aim of this study was to investigate S. pneumoniae carriage rate among dental patients who could, therefore, be responsible for the contamination of the environment during dental therapy, thus promoting acquisition and spread of pneumococci at community level.

## Material and Methods

A consecutive sample was selected from children aged 10-12 years attending the pae-diatric dentistry section of a dental hospital in Rome (Italy). The minimum sample size was estimated assuming S. pneumoniae carriage rate of 8.5%, based on a previous survey among healthy Italian children aged six years[17]. With the highest acceptable margin of error of 5% and confidence interval of 95%, the sample size was set at 119 subjects. The study protocol was approved by the ethic committee of the dental hospital and written informed consent to nasal swabbing and anamnestic data collection was obtained from children's parents or guardians.

The morning of the appointment and before the dental treatment, participating children underwent an oropharyngeal sample which was collected by one of the authors expert in micro-biological procedures and trained for this purpose. The swab was inserted through the mouth and placed on the posterior wall of pharynx and on tonsils for at least five seconds, paying attention not to touch uvula and tongue. Children must not assume antibiotics or other antimicrobials during one week before the sampling occasion and must not drink or eat anything after breakfast. A questionnaire was administered to the parent or guardian by one of the authors and was used to obtain demographic and clinical characteristics of the enrolled children. The questions were 1) development of respiratory

tract infections (RTI- rhinitis, tonsillitis, laryngitis, acute otitis media, sinusitis, acute bronchitis, pneumonia) during the month before the sampling occasion; 2) assumption of antibiotics or other antimicrobial the month before the sampling occasion; 3) daily exposure to passive smoking at home.

The swabs were immediately plated on plates containing Columbia Agar supplemented with 5% sheep blood (Becton Dickinson Italia, Buccinasco, Italy), 5 µg/mL gentamicin and were incubated in 10% $CO_2$ atmosphere at 37°C for 24 h. Alpha-haemolytic colonies were gram stained and tested for bile solubility adding few drops of 2% sodium desoxycholate solution (Becton Dickinson Italia) on some typical colonies. Plates were then incubated at 37°C for 30 min. Disappearance of colonies leaving areas of alpha-haemolysis was indicative of positive test[18]. Further identification tests were not made, therefore, positive samples were considered presumptively positive. This option decreased the internal validity of this study, as uncertainty could lead to S. pneumoniae carriage rate estimate artificially higher or lower than the true rate. For this reason, in order to increase the internal validity of the study leaving unchanged the external validity, that is, the chance to extend the present prevalence estimate to Italian healthy children aged 10-12 years, the power of the test was increased by increasing the sample size from 119 to 186 subjects, which resulted in a decrease in the margin of error from 5% to 4%[19].

Presumptive S. pneumoniae carriage rate was estimated with 95% confidence interval

logistic regression analysis was then used to assess the adjusted ORs. Collinearity between explanatory variables was investigated using the Spearman's correlation coefficient ρ. If values higher than 0.5 were detected, only one of the two variables was used in the regression model. Robustness of results was investigated through pseudo-$R2$ and likelihood ratio $\chi2$ test.

Since the aim of this study was to decrease the chance that airborne pneumococci are spread in the environment of the dental healthcare settings during therapy, thus decreasing the diffusion of these microorganisms at community level, using the coefficients estimated by the multiple regression analysis a probabilistic model was built which provided the chance (expressed in percentage) that a child was S. pneumoniae carrier according to the aforementioned anamnestic variables. Only variables which provided p-values lower than 0.2 in the multiple logistic regression model were considered.

## Results

The study was made between September and December 2011. The number of invited children was 223. Parents or guardians of 24 of them did not provide the consent to swabbing (n=15), anamnestic data collection (n=4), or both (n= 5). One hundred ninety-nine children remained and were included in the sample (participation rate, 89.2%), their mean age was 11.3 years, almost one half of them was aged 12 years. Females were 106 and males 93 (Table 1). Incidence of reported RTIs during the month

**Table 1.** *General characteristics of the 199 sampled children.*

| Variable | Percentage (number) |
| --- | --- |
| Age, 10 years | 21.6% (43) |
| Age, 11 years | 31.2% (62) |
| Age, 12 years | 47.2% (94) |
| Gender, female | 53.3% (106) |
| Gender, male | 46.7% (93) |
| Respiratory tract infections during the last month | 27.1% (54) |
| Antibiotics during the last month | 8.5% (17) |
| Exposure to passive smoking | 35.2% (70) |

(95CI). The association of S. pneumoniae carriage with age class, gender, RTI, routine exposure to passive smoking and recent antibiotic therapy was initially assessed with logistic regression analysis, which provided the odds ratios (ORs) unadjusted for covariates. Multiple

before the sampling occasion was 27%, while 8.5% assumed antibiotics in the same period. Routine exposure to passive smoking was high, namely, 35%.

S. pneumoniae carriage rate was 11.6% (Table 2), with minimal differences between the

three age classes, while carriage rate was higher in males than in females (12.9% vs. 10.4%).

*Table 2. Presumptive S. pneumoniae carriage rate.*

| Variable | Carriage rate (95CI) |
|---|---|
| Age, 10 years | 11.63 (2.03-21.17) |
| Age, 11 years | 11.29 (3.41-19.17) |
| Age, 12 years | 11.70 (5.20-18.20) |
| Gender, female | 10.38 (4.57-16.19) |
| Gender, male | 12.90 (6.09-19.71) |
| Total | 11.56 (7.15-16.05) |

The unadjusted ORs for presumptive pneumococci carriage were non-significant excluding for subjects with recent RTIs (OR, 2.8; 95CI, 1.2-6.9) (Table 3). Exposure to routine passive smoking resulted in a marginally significant association with carriage (unadjusted

Probability of carrying S. pneumoniae was the highest for males routinely exposed to passive smoking and with recent RTIs (58%) (Table 4) and was also high among males with recent RTIs (41%) and females routinely exposed to passive smoking and with recent RTIs (30%). Conversely, in females with no episodes of RTIs and not exposed to passive smoking the chance to carry pneumococci was minimal (6%).

## Discussion

The present study is one of the papers presented at the workshop "Advances in Infection Epidemiology and Control in Dental Healthcare

*Table 3. Unadjusted and adjusted odds ratios (ORs) of the effects of age, gender, incidence of RTIs during the last month, use of antibiotics during the last month and routine exposure to passive smoking on carriage of presumptive S. pneumoniae.*

| Variable | Anadjusted OR (95CI) | Adjusted OR (95CI) |
|---|---|---|
| Age, 11 years | 0.97 (0.29-3.28) | 0.69 (0.19-2.59) |
| Age, 12 years | 1.01 (0.33-3.10) | 0.40 (0.06-2.79) |
| Gender, male | 1.28 (0.54-3.06) | 3.22 (0.61-17.10) |
| Respiratory tract infections during the last month | 2.84 (1.17-6.89)* | 3.34 (1.28-8.67)* |
| Antibiotics during the last month | 0.46 (0.06-3.60) | 0.53 (0.06-4.45) |
| Exposure to passive smoking | 1.82 (0.76-4.37) | 1.98 (0.80-4.88) |

*statistically significant at 95% level
Multiple logistic regression model: Pseudo R2: 0.068. Likelihood ratio $\chi^2$ 6df: 9.70; p=0.13

OR, 1.82; 95CI, 0.8-4.4; p=0.18). Adjustment for covariates provided an increase in the OR estimates for the most important variables, that is, recent RTIs (OR, 3.3; 95CI, 1.3-8.7), routine exposure to passive smoking (OR, 2.0; 95CI, 0.8-4.9) and male gender (OR, 3.2; 95CI, 0.6-17.1). These three variables were associated with pneumococci carriage with p<0.20 and were used in the probability model.

Settings", Department of Public Health and Infectious Diseases, Sapienza University, Rome, Italy on February 9th, 2013[20-26].

The estimated S. pneumoniae carriage rate in healthy preadolescents was between 7% and 16%, suggesting that these microorganisms are likely to be spread in dental healthcare settings. Carriage rate studies in young individuals are not frequent. Oropharyngeal carriage rate among 179 medical students from Turkey

*Table 4. Probability of carrying S. pneumoniae according to gender, incidence of RTIs during the last month and routine exposure to passive smoking. Categories were ordered according to decreasing probability.*

| Gender | Respiratory tract infections | Passive smoking | Probability (%) |
|---|---|---|---|
| Male | Yes | Yes | 58.2% |
| Male | Yes | No | 41.3% |
| Female | Yes | Yes | 30.2% |
| Male | No | Yes | 29.4% |
| Female | Yes | No | 17.9% |
| Male | No | No | 17.4% |
| Female | No | Yes | 11.4% |
| Female | No | No | 6.1% |

was close to 20%[27], but it was 0% among 79 medical students from Austria[28]. Studies investigating environmental contamination reported consistent results. Indeed, in a Mexican dental clinic pneumococci were detected in 1% of samples from the cellular phones of staff and patients[29], while in US, Israeli and Austrian healthcare settings[30,31] they were not detected. These data collectively suggest that S. pneumoniae carrying dental patients and staff are moderately frequent and that pneumococci are not easily detectable in the environment of healthcare settings. Therefore, S. pneumoniae infections potentially acquired in dental healthcare settings are probably not transmitted by dental healthcare workers.

As previously noted, studies on the risk for S. pneumoniae infection among dental patients and staff are lacking. Therefore, it is not possible to make any convincing speculation regarding the necessity of specific control measures. The present data allowed to design the profile of potential S. pneumoniae carriers among young dental patients. Indeed, male subjects with recent RTI and daily exposure to passive smoking are more likely to be S. pneumoniae carriers. These predisposing characteristics are corroborated by a previous Italian study made on young children[17]. In special dental healthcare settings where immune-compromised patients are generally treated, such as elderly, hospitalized patients, HIV positive subjects, oncologic patients, it is advisable to apply the so called transmission-based precautions[32]. Pneumococcal vaccination is one of these precautions, although polysaccharide pneumococcal vaccines do not seem totally effective in preventing invasive pneumococcal disease and death 33 and the Infectious Disease Society of America does not recommend vaccination in any category of healthcare workers, therefore including dental healthcare workers, but recommends vaccination for adults older than 65 years[34]. Influenza vaccination, useful in preventing HCAP and CAP, including those cases attributable to S. pneumoniae, is probably more adequate in preventing pneumococcal transmission and infection, because it decreases the probability to develop RTIs.

## Conclusion

The present study demonstrated that S. pneumoniae carriage rate in healthy preadolescent dental patients was moderately high and that such rate is higher in subjects with history of recent RTIs. Patient's profile could be helpful to identify potential carriers and to adopt transmission-based precautions, although the risk for infection for dental patients and staff is unknown. It is prudent that control of airborne microorganisms and pneumococcal and influenza vaccinations are made by dental healthcare workers who practice in special care units.

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