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Risk factors associated with asthma phenotypes in dental healthcare workers

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Abstract

Background—Exposure in the dental environment can increase the risk of respiratory disease in dental healthcare workers (HCWs). This study investigated the prevalence of asthma phenotypes in dental HCWs and associated risk factors.

Methods—A cross-sectional study of 454 dental HCWs in five dental institutions in South Africa was conducted. A self-administered questionnaire elicited the health and employment history of subjects. Sera was analysed for atopic status and latex sensitization. Pre and post bronchodilator spirometry was performed.

Results—The prevalence of atopic asthma was 6.9%, non-atopic asthma 5.9% and work-exacerbated asthma (WEA) 4.0%. Atopy and work-related ocular-nasal symptoms were strong predictors of WEA (OR: 3.4; 95% CI: 1.07–10.8; OR: 6.7, 95% CI: 2.4–19.1), respectively. Regular use of personal protective equipment (PPE) was associated with a protective affect (OR: 0.23, 95% CI: 0.1–0.7) among non-atopic asthmatics, while glove use and respiratory protection was protective among atopic asthmatics (OR: 0.39, 95% CI: 0.17–0.89).

Conclusion—Identification of risk factors associated with specific asthma phenotypes in dental HCWs can be used to focus preventive strategies for asthmatics.

Keywords

work-related asthma; asthma phenotypes; dental workers; risk factors; latex

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INTRODUCTION

Asthma a common disease of the airways has been described as a spectrum of phenotypes, as a result of the interaction between genetic and environmental factors [Hargreave and Parameswaran 2006, Oryszczyn, et al. 2007, Wardlaw, et al. 2005]. Asthma commonly presents as a complex of multiple, separate syndromes that overlap. Phenotypes may be defined by clinical or physiological criteria, environmental triggers, or by pathobiology based on patterns of inflammation, specifically the presence or absence of particular inflammatory cell types [Wenzel 2006].

Various studies have suggested that exposure in the dental environment, in particular dental workplace aerosols, increases the risk of respiratory disease in dental healthcare workers (HCWs) and patients [Scannapieco, et al. 2004]. The prevalence of self-reported asthma among dentists (100 from rural Northern Ireland, 166 from London) working in general practice was reported to be 14% [Pankhurst, et al. 2005]. In a sub-population of this study, dentists who were exposed to aerobic counts of concentrations 200 cfu/ml in their dental surgery were more likely to report symptoms of asthma since commencement of employment. The study suggested that the temporal onset of asthma may be associated with occupational exposure to contaminated dental unit waterlines (DUWLs).

Dental personnel also use or come into contact with many potential allergens and irritants in the course of their work [Gawkrödger 2005]. Common causative agents implicated in asthma in this group of professionals include natural rubber latex (NRL) [Agrawal, et al. 2010, Henriks-Eckerman, et al. 2001], methacrylates [Jaakkola, et al. 2007, Quirce, et al. 2001] and more recently endotoxin [Dutil, et al. 2009, Huntington, et al. 2007, Szymanska 2005]. Various other studies assessed the relation between occupation and risk of developing asthma and have demonstrated an increased risk of asthma among dental workers (including dentists and dental assistants) [Jaakkola, et al. 2003, Le Moual, et al. 2004]. A cross-sectional study of French dental technicians also showed an increased prevalence of respiratory symptoms but the actual causes were not investigated [Radi, et al. 2002]. None of these studies have reported on the various asthma phenotypes encountered in dental HCWs.

The aim of our study was to determine the prevalence of various asthma phenotypes in dental HCWs based on environmental and work-related triggers and clinical presentation, and to determine the host and work-related risk factors associated with these asthma phenotypes.

This study is part of a larger study including a detailed environmental exposure assessment study that is the subject of a separate communication [Singh, et al. 2010].

MATERIALS AND METHODS

Study design, population and sampling

A cross-sectional study of approximately 1816 currently employed dental healthcare workers and registered students was conducted in five academic dental institutions situated

in four provinces of South Africa during the period 2005 to 2008. A total number of 454 individuals (25%) were selected to participate in the study. Among this group, 164 (36%) were dental students and 290 (64%) were registered clinical and non-clinical staff. There were 33 workers who had incomplete data and were therefore excluded from the final data analysis as outlined below. The study was approved by the University of the Witwatersrand, Human Research Ethics Committee (Medical) (Johannesburg, South Africa) and the Institutional Review Board of the University of Michigan (MI, USA).

Health and employment questionnaire

The study collected information on important demographic factors. Each participant answered a modified questionnaire specifically designed for the investigation of asthma, contained in the Protocol for the European Community Respiratory Health Survey [European Community Respiratory Health Survey 1993] and recent study of seafood-processing workers [Jeebhay, et al. 2008]. It addressed work-related respiratory symptoms and a history of previous medical illnesses. Other questions included employment history, degree of exposure to aerosols and smoking status. Smoking status was classified into three categories namely: non-smoker for lifelong abstinence from smoking; ex-smoker if the subject ceased smoking completely more than one month before the survey; and current smoker. Symptom variables that were evaluated for their relationship to work included: respiratory (wheeze and/or tight chest); ocular (itchy eyes, red eyes); and nasal (runny nose, blocked nose/stuffy nose) symptoms. Work-related asthma symptoms were defined as an affirmative response to the question: "Does being at work ever make your chest tight or wheezy?". The case definition for self-reported asthma was a positive response to one or a combination of the following: "Have you had an attack of asthma in the last 12 months?", and "Are you currently taking any medication for asthma?".

Serum analysis for Phadiatop, recombinant latex and latex-specific IgE levels

A blood sample was obtained from workers using a Becton Dickinson Vacutainer CAT tube (with clot activator). Samples were left to coagulate for 3–6 hours at room temperature and were then centrifuged at 1500 g for 10 minutes. The serum was transferred into 5 ml plastic cryotubes (Nunc, Denmark) and placed in storage at –20°C until transported to the laboratory and then stored at –70°C until analysis. Serum analysis for common inhalants using Phadiatop® test and latex-specific IgE (k82) (*Hevea brasiliensis*) determinations from participants (n = 421) were performed. Specific IgE to individual recombinant latex allergens (n = 85) (Hev b 1, Hev b 3, Hev b 5, Hev b 6.01, Hev b 6.02, Hev b 8, Hev b 9, Hev b 11) as well as cross-reacting carbohydrate determinants (CCDs) (horse radish peroxidase (HRP) and bromelain (MUXF3)) were performed on workers (n = 41) with a positive response to latex (k82) as well as those who reported latex-related symptoms (n = 35) and healthy controls (n = 9). Maltose-binding protein (MBP) was also included in the analysis as a negative control. Tests were done according to the manufacturer's instructions using the ImmunoCAP system 100 (Phadia AB, Uppsala, Sweden). A value of 0.35 kU/l was considered positive. Data from 33 subjects were not included in the analysis for various reasons including haemolysed specimens, insufficient serum or no sample provided for religious reasons.

Spirometry

Spirometry was conducted according to the American Thoracic Society (ATS) guidelines [American Thoracic Society (ATS) 1995]. A Jaeger Masterscope spirometer (Höchberg, Germany), calibrated at least twice a day with a 3 L syringe, was used. The tests were conducted by trained technologists. Each participant performed up to eight trials to produce three acceptable curves, in a sitting position without nose clips. Test reproducibility was used as a guide to whether further attempts were necessary. Reproducibility criteria included the two best tracings for both forced expiratory volume in one second (FEV₁) and forced vital capacity (FVC) varying by no more than 0.2 L [van Schalkwyk, et al. 2004]. However, failure to meet reproducibility criteria did not result in exclusion of the spirogram results from the statistical analysis. Poor reproducibility may also be an independent marker of airway dysfunction [Becklake and White 1993]. The lung function indices of primary interest included FEV₁ and FVC. The best FEV₁ and FVC readings were used regardless of whether they belonged to the same tracing. Measurements obtained by spirometry were adjusted according to the temperature and atmospheric pressure measured throughout the day. Special instructions were given to workers to ensure that they did not smoke tobacco (at least 1 hour) and did not use any anti-asthmatic inhalers (4 hours) or take oral asthma medications (8 hours) prior to the test. Workers' heights were recorded for calculating predicted lung function indices using reference values of the European Community for Coal and Steel with lower limits corresponding to the 95th percentile [Quanjer, et al. 1993]. Exclusion criteria included pregnancy, nursing mothers, epilepsy, recent (3 months prior) stroke or heart attack, recent (3 weeks prior) respiratory tract infection, TB diagnosis and very high blood pressure. Nine participants were excluded from doing spirometry due to these reasons. For the remaining 24 individuals, spirometry was not recorded due to loss of follow up. Post-bronchodilator tests were conducted on the majority of subjects who participated in the baseline test with the exception of 18 subjects where this was not logistically possible. The bronchodilator test was done using inhaled beta-2 agonists (salbutamol, 400 µg). An improvement of at least 12% and 200 ml after administration of salbutamol was regarded as a significant response. The post-bronchodilator test was done at least 10 minutes after administration of the bronchodilator. Both pre-and post-bronchodilator FEV₁ had to be reproducible for calculating the degree of the bronchodilator response.

Operational definitions of asthma phenotypes

Atopic asthma was defined as either having an asthma attack or use of asthma medication in the past 12 months or positive bronchodilator test (increase in FEV₁ and/or FVC ≥ 12% and 200 ml increase compared with baseline); and presence of atopy (defined as positive response to Phadiatop test). Non-atopic asthma was defined as either having an asthma attack or use of asthma medication in the past 12 months or positive bronchodilator test (increase in FEV₁ and/or FVC ≥ 12% and 200 ml increase compared with baseline); and absence of atopy. Work-exacerbated asthma (WEA) was defined as either having an asthma attack or use of asthma medication in the past 12 months or positive bronchodilator test (increase in FEV₁ and/or FVC ≥ 12% and 200 ml increase compared with baseline) and the presence of work-related chest symptoms (tight chest or wheezing when at work or job change due to work-related symptoms or improvement after changing jobs) [Baatjies, et al. 2009, Jeebhay, et al. 2008].

Statistical analysis

Summary descriptive statistics of demographic and occupational variables, immunological and respiratory measurements and study outcomes were done. Exploratory bivariate analyses were used to assess the nature of the associations between outcomes and covariates. Multiple logistic regression analysis was carried out to assess the association between risk factors (host and occupational risk factors) and the definitions of asthma. Odds ratios were used as the measure of effect and were estimated together with 95% confidence intervals (CIs). In this study we adjusted for potential confounders, including age, sex and smoking status. The key disease outcome variables of interest were atopic asthma, non-atopic asthma and WEA. Statistical analyses were performed using STATA version 9 computer software (StataCorp, 2007, Texas, USA).

RESULTS

Demographic and occupational characteristics

The mean age of study participants was 36 years and 74% of study participants were female (Table I). The majority of the subjects were non-smokers (79%), 13% were current smokers of whom the average age when they started smoking was 20 years. The average employment duration in the current job was 10 years. A large proportion (~50%) of the study population reported being exposed to sprays from dental drills in the work environment and worked close (< 1 m) to the source of exposure. There were 22% who reported excessive exposure (i.e. exposure exceeding that thought to be normal or usual) and 18% experienced chest symptoms due to peak exposures (i.e. the largest amount of exposure that a person is exposed to at one time). There were 65% of participants who reported regularly using personal protective equipment (PPE), which included gloves, respiratory protection (surgical mask), goggles and laboratory coats. Most clinic staff and students (95%) in the dental clinics and the laboratories regularly used PPE whereas only 78% of cleaning staff wore PPE. Almost half of the subjects reported wearing powdered latex gloves while only 5% used non-latex gloves.

Self-reported medical history, including asthma and latex allergy

Twenty percent of the study participants reported recent chest infections with 7% reporting pneumonia (Table II). A history of ocular-nasal and chest symptoms as a result of environmental triggers was reported by almost a third of the participants. Among family history of allergies, hay fever (21%) was the most prevalent condition followed by asthma (19%).

Doctor-diagnosed asthma (self-reported) was reported in 12% of the study participants (Table II). Among these subjects approximately one third developed asthma after the age of 17 years and only half reported being on asthma medication at the time. Asthma-related symptoms for the purpose of this study was relatively high (30%) compared to doctor-diagnosed asthma. Interestingly, 71% of those with self-reported asthma-related symptoms developed symptoms after the age of 17 years. There were 4% of subjects who reported chest tightness when at work. Among the 311 latex-exposed individuals approximately 10% experienced upper respiratory tract symptoms, while 7% reported lower respiratory tract

symptoms. However, only 3% reported latex related symptoms. Symptoms associated with domestic exposure to latex products were reported in 6–11% of subjects (data not shown).

Immunological characteristics

Almost half of the study population (46%) was atopic as demonstrated by positive Phadiatop test (Table III). Latex sensitization to composite latex (k82) extract was demonstrated in 10% of the subjects however, only 7% demonstrated true latex sensitization after those with positive reactions to CCDs were excluded. This implies that 3% of workers with reactivity to composite latex extract (k82) demonstrated a false-positive reaction to latex. Fourteen percent of dental workers were sensitised to Hev b 8 followed by 12% sensitised to Hev b 6.01. The prevalence of sensitization to Hev b 5 was demonstrated in 4% of workers. The prevalence of latex-related allergic ocular symptoms was 11%, nasal symptoms 10% and asthma symptoms 0.9%.

Pulmonary function outcomes of dental healthcare workers

The mean FEV₁ of the entire group was 2.76 L, with the standardized lung function indices slightly better in women than men (Table IV). Nineteen percent of subjects had a baseline FEV₁ less than 80% predicted. However, there were 5% of workers with reversible airway obstruction indicative of asthma and 4% with possible COPD.

Risk factors for various asthma phenotypes

The prevalence of atopic asthma and non-atopic asthma among dental HCWs was 6.9% and 5.9%, respectively (Table V). A lower prevalence (4.0%) was demonstrated for WEA. In the multivariate logistic regression models, after adjusting for age, sex and smoking status, a history of pneumonia (OR = 3.47, 95% CI: 1.17 – 10.33) was significantly associated with atopic asthma. Dental HCWs with atopic asthma were four times more likely to have ocular-nasal symptoms (OR = 4.43, 95% CI: 1.92 – 10.25) and five times more likely among HCWs with WEA (OR = 5.88, 95% CI: 1.94 – 17.81). Atopy (OR = 3.40, 95% CI: 1.07 – 10.83) was identified as a significant predictor of WEA. Past history of tuberculosis (OR = 1.05, 95% CI: 1.01 – 1.09) was a significant predictor of non-atopic asthma. The regular use of PPE of any type was protective for non-atopic asthma (OR = 0.23, 95% CI: 0.08 – 0.68) while glove use was protective for atopic asthma (OR = 0.39, 95% CI: 0.17 – 0.89). Of interest is the significant association between latex sensitization and non-atopic asthma (OR = 1.04, 95% CI: 1.01 – 1.08).

DISCUSSION

In this study of dental HCWs the prevalence of atopic asthma (6.9%) was very similar to non-atopic asthma (5.9%). These findings are consistent with other studies, which demonstrated that only 50% of asthma is attributable to eosinophilic inflammation as is found in atopic asthma [Douwes, et al. 2002]. The findings suggest that other agents [Fahy, et al. 1995] aside from common inhalant allergens play a role in the development of asthma in dental HCWs. Aerosolised products and materials that can irritate the respiratory tract include acrylic dusts, filling composites, disinfectant agents as well as biological agents such

as endotoxin [Pankhurst, et al. 2005, Robert-Sauve Research Institute for Occupational Safety and Health 2001].

The prevalence of WEA was slightly lower (4.0%) in this study population. Among the work-exacerbated asthmatics a larger proportion was atopic (59%) than non-atopic (35%). A previous study showed that the prevalence of workplace exacerbation of asthma in the medical services was up to 26% [Henneberger, et al. 2002]. The prevalence of work-related asthma (WRA) in this study is in the lower range of estimates (5 – 19%) for adult asthma attributable to occupation [Tarlo 2008]. The prevalence is also lower than that reported in private dentists (14%) with self-reported asthma since starting training [Pankhurst, et al. 2005]. HCWs including dental workers accounted for 16% of 1879 confirmed WRA cases from a surveillance study in four American states [Pechter, et al. 2005]. The distribution of exposures for this group included cleaning products, latex, glutaraldehyde, formaldehyde and acrylates. Acrylates (acrylic resin-based composites and bonding agents) used in dental fillings are known to play a role in both allergies and asthma [Hagberg, et al. 2005]. The risk of adult-onset asthma, nasal symptoms and other respiratory symptoms increase significantly with daily use of methacrylates in dental assistants' work [Jaakkola, et al. 2007]. Dental workers in our study group were also likely to be exposed to acrylates during dental conservation/restoration procedures where teeth are filled with acrylic based compounds [Marquardt, et al. 2009]. As the tooth is filled and shaped, dust particles are generated, that may contribute towards these agents becoming airborne and more readily inhaled. One of the limitations of this study is that acrylate exposures were not quantifiable as there were no reliable laboratory methods readily available in South Africa at the time of the study. Due to its allergic or inflammatory potential, exposure to acrylates should be kept as low as possible in order to reduce the incidence of occupational respiratory disease.

Various host factor attributes have been associated with asthma. These include age [Caldeira, et al. 2006, Miranda, et al. 2004], atopy [Mapp, et al. 2005], cigarette smoking [Haahtela, et al. 2006, Haldar and Pavord 2007, Jeebhay and Quirce 2007, Mapp, et al. 2005], sex [Bakke and Gulsvik 2000, Haahtela, et al. 2006, Jeebhay and Quirce 2007] and obesity [Bousquet, et al. 2008]. In this current study atopy was shown to be a significant predisposing factor for WEA in the multivariate regression model (OR = 3.4, 95% CI: 1.07 – 10.83). Previous studies have shown that atopy is an important risk factor for WRA, especially occupational asthma due to high molecular weight (HMW) agents [Caldeira, et al. 2006, Cartier 1998]. That, atopy is associated with WEA suggests that other non-specific triggers may aggravate asthma in individuals with atopic asthma.

Ocular-nasal symptoms were strongly associated with the atopic asthma (OR = 4.43, 95% CI: 1.92 – 10.25) and WEA (OR = 5.88, 95% CI: 1.94 – 17.81) phenotypes in this study. An even stronger association was observed between work-related ocular-nasal symptoms and WEA (OR = 6.70, 95% CI: 2.35 – 19.13). Possible agents in this setting that could contribute to these symptoms include methacrylates [Toren 2007], rubber products, metals, resins and latex [Gawkrödger 2005]. Recent studies have concluded that rhinitis is a significant and independent risk factor for adult-onset asthma of atopic or non-atopic origin [Guerra, et al. 2002] and work-related ocular-nasal symptoms can aggravate pre-existing asthma [Arif, et al. 2003, Fishwick, et al. 2008]. Rhinoconjunctivitis symptoms often

precede the onset of asthma symptoms among workers exposed to HMW agents [Arif, et al. 2003]. Although it is usually considered a mild disease, these workers should be considered a high-risk group [Karjalainen, et al. 2003] because of the likelihood of developing occupational asthma [Malo, et al. 1997].

In this current study, one third of dental HCWs used powdered latex gloves, although only 3% had self-reported latex allergy. Although 10% were sensitised to the composite latex extract, only 7% demonstrated true latex sensitization. The differentiation between true latex sensitivity and cross-reactivity was based on the presence of allergic specific IgE antibodies to latex and use of CCD markers. The prevalence of latex allergy among dental professionals in a previously published study ranged between 8.8 to 13% [Saary, et al. 2002]. In the current study 65 workers (14.3%) had latex-allergic ocular-nasal symptoms and only four workers (0.9%) had latex-related allergic asthma symptoms. This is lower than the prevalence (1.2% – 16.3%) for rhinoconjunctivitis in NRL exposed healthcare worker populations [Fish 2002]. The prevalence of latex-related allergic asthma symptoms is also lower than the prevalence of 2.5% among hospital workers exposed to NRL [Vandenplas, et al. 1995]. This low prevalence indicates that exposures to other workplace agents aside from latex need to be considered in WRA. Other studies showed that the prevalence of respiratory illness, including asthma, among dental students in North America and Canada is between 1.7–5.5% [Scannapieco, et al. 2004]. Interestingly, latex sensitization appeared to be more strongly associated with the non-atopic asthmatic phenotype in this study, which merits further investigation.

A past history of pneumonia was a significant risk factor of atopic asthma (OR = 3.47, 95% CI: 1.17 – 10.33) and WEA (OR = 15.86, 95% CI: 5.14 – 48.94). Various infectious diseases such as *Chlamydia pneumoniae* and *Mycoplasma pneumoniae* are important factors in the occurrence of asthma and may have a bi-directional effect on the development of allergy and asthma [Douwes, et al. 2002]. For non-atopic asthma a previous history of pulmonary TB is a strong determinant (OR = 1.05, 95% CI: 1.01 – 1.09). Other studies have also shown that long-term exposure to microbial agents from the spray/mist is associated with an increased risk of asthma [Pankhurst, et al. 2005]. These sprays are generated by high speed air turbine dental drills [Oppenheim, et al. 1987]. During clinical dental procedures, high-frequency vibrations are transferred to the working tip of the drill creating frictional heat which is prevented by water circulation through the handpiece, exiting the tip, as a spray [King, et al. 1997]. The spray may contain particles carrying microorganisms, irritants, allergens and other toxic substances capable of producing acute and chronic respiratory problems. Depending on their size, these particles can remain airborne as aerosols or settle quickly on surfaces or objects intercepting their fall [Osorio, et al. 1995]. In our study, over half the study participants (53%) were exposed to sprays at work with 50 – 60% working in close proximity to the source of exposure. Among these workers 22% complained of excessive exposure to these sprays. However, we were not able to demonstrate any association between excessive exposure to these sprays and the various asthma phenotypes. The reason for the close relationship between respiratory infections and respiratory allergic diseases is not known [Chen, et al. 2000]. This may be due to a switch in the T_H1/T_H2 balance from

T_H1 which is initially stimulated by bacterial infection but suppressed by disease progression to a T_H2 mechanism [Howell, et al. 2004].

The current study also demonstrated that the regular use of PPE of any type was protective for all asthma phenotypes with strong association observed for non-atopic asthma (OR = 0.23, 95% CI: 0.08 – 0.68). Furthermore, use of gloves (OR = 0.39, 95% CI: 0.17 – 0.89) and respiratory protection (surgical mask) (OR = 0.39, 95% CI: 0.17 – 0.89) were specifically protective for atopic asthma. It is likely that use of personal protective equipment may have decreased the exposure to potential irritants/allergens as well as non-specific triggers such as bioaerosol exposure. However, these results must be interpreted in the context of other issues related to validating user compliance or of timing of exposures in relation to the use of PPE, since these protective measures were not formally introduced or evaluated in this cross-sectional study.

In conclusion, the results of this study have demonstrated that several factors determine the manifestation of the various asthma phenotypes. Closer focus on these factors may improve our understanding of the manifestation of the specific asthmatic phenotype, which will improve the management of dental HCWs presenting with asthma and to prevent new onset adult asthma in the workplace. The identification of various phenotypes of asthma is particularly important in the dental setting as workers are exposed to multiple agents that may cause asthma through various mechanisms. The pathophysiological basis for these different clinical phenotypes needs to be explored further so as to identify more specific causes for the asthma observed in this group of workers. No interventions to reduce exposure were done during this study.

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Table I

Demographic characteristics of dental healthcare workers in South Africa

Demographic characteristics	Overall N = 454
Age (years)	36 ± 13.3
Sex: female : male (%)	74 : 26
Smoking history: no. (%)	
- Current	53 (13%)
- Ex-smoker	31 (8%)
- Non-smoker	319 (79%)
- Average number of years smoked	12 ± 10.0
- Average age when started smoking (years)	20 ± 6.8
Employment duration in current job (years)	10 ± 9.1
Employment duration in current clinic (years)	9 ± 8.3
Employment duration prior to current employment (years) (n = 129)	7 ± 6.5
Number of patients consulted per day	16 ± 20
Staff clinical working hours per day	8 ± 2.3
Occupational exposure to	
- Spray	240 (53%)
- Mist	26 (6%)
- Steam	14 (3%)
- Dust	5 (1%)
Extent of occupational exposure	
- Excessive (most of the day)	98 (22%)
- Regular (thrice a week)	124 (27%)
- Minimal (once a week)	90 (20%)
- Nil	142 (31%)
Distance from source of exposure	
- Right next to the source (<1 m)	229 (50%)
- About 1–2 m	44 (10%)
- More than 2 m	34 (40%)
Episode of peak exposure causing tight chest, wheeze or cough	83 (18%)
Regular use of PPE	297 (65%)
- Goggles	180 (40%)
- Gloves	311 (69%)
- Respiratory protection (surgical mask)	280 (62%)
- Laboratory coats	252 (56%)
Type of gloves used (n = 311)	
- Powdered latex	150 (48%)
- Powder-free low-protein latex	65 (21%)
- Non-latex	14 (5%)
- Combination of > 1 type	82 (26%)
Contact with latex containing products at work	311 (83%)

Note: Continuous variables- mean $\pm$ SD; Categorical variables- number (%)

Table II

Self-reported medical history and airway symptoms among dental healthcare workers in South Africa

Characteristics	Prevalence (%) (N=454)
<i>Past medical history</i>	
- Recent chest infections	93 (20%)
- Pneumonia	31 (7%)
- Tuberculosis	10 (2%)
- Chronic bronchitis	5 (1%)
<i>Family history of allergy</i>	
- Hay fever	95 (21%)
- Asthma	84 (19%)
- Eczema	58 (13%)
<i>Upper airway symptoms</i>	
- Ocular-nasal symptoms	137 (30%)
- Work-related ocular-nasal symptoms	65 (14%)
<i>Asthma history and symptoms</i>	
Doctor-diagnosed asthma (self reported)	56 (12%)
- Before 17 years	36 (8%)
- After 17 years	20 (4%)
Current use of asthma medication	25 (6%)
Asthma-related symptoms (in the last 12 months)	135 (30%)
<i>Work-related asthma symptom experience</i>	
- Tight chest or wheezing when at work	17 (4%)
- Tight chest or wheezing after peak exposures	83 (18%)
- Job change due to work-related chest symptoms	7 (2%)
- Improvement after changing jobs	6 (1%)
<i>Symptoms associated with work-related latex exposure</i>	
- Ocular (itchy eyes)	48 (11%)
- Nasal (runny or blocked nose)	46 (10%)
- Chest (cough, wheeze, difficulty breathing)	33 (7%)

Table III

Patterns of sensitization among dental healthcare workers in South Africa

Allergic sensitization	Prevalence (%)
Atopy (Phadiatop positive) (n = 421)	193 (46%)
Latex (k82) (n = 421)	41 (10%)
Recombinant latex allergens (n = 85)	
- Hev b 1	0 (0%)
- Hev b 3	0 (0%)
- Hev b 5	3 (4%)
- Hev b 6.01	10 (12%)
- Hev b 6.02	6 (7%)
- Hev b 8	12 (14%)
- Hev b 9	1 (1%)
- Hev b 11	2 (2%)
CCD markers	
- MUXF3	13 (15%)
- HRP	18 (21%)
True latex sensitization ¹	29 (7%)
Chloramine T (n = 69) ²	2 (0.5%)

CCD – cross-reacting carbohydrate determinants; MUXF3 – Bromelain; HRP – horse radish peroxidase

¹True latex sensitization refers to positive response to latex (k82) and negative response to CCDs.²Only subjects who reported work-related allergic symptoms were tested.

Table IV

Pulmonary function indices among dental healthcare workers in South Africa

Pulmonary function indices	Overall (N = 421)
Entire group	
-FEV ₁ (litres)	2.76 ± 0.7
-FVC (litres)	3.26 ± 0.9
-FEV ₁ % predicted	93 ± 16.4
-FVC % predicted	94 ± 17.0
-FEV ₁ /FVC %	85 ± 8.4
-No. with initial FEV ₁ < 80% predicted	84 (19%)
-Proportion with FEV ₁ /FVC 0.7	17 (4%)
-Proportion with FEV ₁ post-bronchodilator increase 12% and 200 ml increase	21 (5%)
Males (n = 102)	
-FEV ₁ (litres)	3.39 ± 0.6
-FVC (litres)	4.08 ± 0.8
-FEV ₁ % predicted	91 ± 15.0
-FVC % predicted	92 ± 16.0
-FEV ₁ /FVC %	84 ± 7.6
Females (n = 310)	
-FEV ₁ (litres)	2.55 ± 0.6
-FVC (litres)	2.99 ± 0.7
-FEV ₁ % predicted	94 ± 16.8
-FVC % predicted	95 ± 17.2
-FEV ₁ /FVC %	86 ± 8.6

Continuous variables-mean ± SD; Categorical variables-number (%); Reference values are from the ECCS, 1993. FEV₁: forced expiratory volume in 1 second; FVC: forced vital capacity.

Table V

Environmental and host risk factors associated with asthma phenotypes among dental healthcare workers in multivariate regression models

Characteristics	Asthma Phenotypes, OR (95% CI)		
	Atopic asthma (6.9%) n = 29	Non-atopic asthma (5.9%) n = 25	Work-exacerbated asthma (4.0%) n = 17
Atopy	n/a	n/a	3.40 (1.07 – 10.83) *
Asthma history			
- Family history of asthma	1.89 (0.68 – 5.24)	1.20 (0.24 – 5.99)	1.94 (0.54 – 7.03)
- Childhood-onset asthma (< 17 years)	0.63 (0.17 – 2.34)	1.11 (0.98 – 1.26)	0.26 (0.06 – 1.09)
- Number of asthma attacks in past 12 months	0.39 (0.11 – 1.30)	6.43 (0.57 – 72.05)	0.70 (0.23 – 2.16)
Past medical history			
- Pneumonia	3.47 (1.17 – 10.33) *	2.42 (0.64 – 9.17)	15.86 (5.14 – 48.94) **
- Tuberculosis	2.19 (0.249 – 19.30)	1.05 (1.01 – 1.09) *	2.02 (0.23 – 17.99)
- Recent chest infections	0.71 (0.23 – 2.15)	0.94 (0.30 – 2.99)	1.26 (0.38 – 4.12)
Upper airway symptoms			
- Ocular-nasal symptoms	4.43 (1.92 – 10.25) **	0.58 (0.19 – 1.79)	5.88 (1.94 – 17.81) *
- Work-related ocular-nasal symptoms	1.85 (0.70 – 4.89)	0.99 (0.28 – 3.54)	6.70 (2.35 – 19.13) **
Occupational exposures			
- Student versus staff status	0.62 (0.19 – 2.01)	1.73 (0.37 – 8.16)	0.84 (0.16 – 4.39)
- Spray, mist or steam at work	5.11 (0.52 – 50.23)	9.57 (0.21 – 426)	4.48 (0.44 – 45.31)
- Regular use of PPE	0.73 (0.19 – 2.76)	0.23 (0.08 – 0.68) *	0.45 (0.13 – 1.56)
- Glove versus no glove use	0.39 (0.17 – 0.89) *	0.61 (0.23 – 1.61)	0.74 (0.25 – 2.22)
- Latex versus non-latex glove use	0.72 (0.32 – 1.60)	0.78 (0.31 – 1.96)	1.68 (0.59 – 4.81)
- Respiratory protection (surgical mask) versus no respiratory protection	0.39 (0.17 – 0.89) *	0.61 (0.23 – 1.61)	0.74 (0.25 – 2.22)
Employment duration (< 10 years as baseline)			
- 11 – 20 years	1.70 (0.48 – 5.96)	0.35 (0.07 – 1.82)	0.61 (0.11 – 3.37)
- > 20 years	1.92 (0.45 – 8.17)	1.53 (0.43 – 5.39)	1.99 (0.46 – 8.70)
Allergic sensitization			
- Sensitization to composite latex (k82) extract	1.49 (0.47 – 4.69)	1.04 (1.01 – 1.08) *	0.78 (0.10 – 6.39)
- True latex sensitization	1.58 (0.43 – 5.81)	1.04 (1.01 – 1.08) *	1.22 (0.15 – 10.10)

Each OR is derived from a separate model adjusted for age, sex, smoking.

*
< .500
> .1000