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Rhinopharyngitis and ENT morbidity among cement workers with long-term occupational exposure in Kongo Central Province, DRC

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ABSTRACT

Introduction
Cement mineral dust contains a variety of carcinogenic and non-carcinogenic substances that contribute to serious health effects.

Purpose
This study aimed to determine the ENT symptoms and diagnoses among workers exposed to cement dust.

Methods
A cross-sectional study was conducted between July and August 2024 among 270 workers in the exposed group (production, maintenance, transport, and handling workers) and 32 workers in the less exposed group (administrative staff and laboratory technicians) from the Kongo Cement Plant (CIMKO) in the DRC. A pre-designed questionnaire on ENT pathologies was administered to participants. Otoscopy, anterior rhinoscopy, and audiometry were performed. NO_2 (µg/m³) and SO_2 (µg/m³) concentrations were measured. Multivariate analysis was performed to determine the association between occupational exposure to cement dust and ENT symptoms and diagnoses.

Results
The annual average concentration of SO_2 was higher in the exposed group (15.54 µg/m³) and exceeded the threshold limit value (TLV) of the occupational exposure limit (OEL) adopted by NIOSH (2 ppm; 5 µg/m³). The exposed group had more than a sevenfold increased risk of pharyngitis, adjusted odds ratio (aOR) 7.4 (3.3–16.8), and more than a twofold increased risk of rhinitis, aOR 2.4 (1.4–4.1). Rhinosinusitis more than doubled the risk of presenting with pharyngitis and rhinitis, aOR 2.5 (1.6–3.9) and aOR 2.7 (1.2–6.5), respectively. Similarly, a duration of employment of ≥ 2 years increased the risk of pharyngitis more than fivefold, aOR 5.3 (3.6–15.2), and rhinitis more than threefold, aOR 3.6 (2.1–5.8).

Conclusions
Occupational exposure to cement dust was associated with ENT diagnoses, particularly a higher risk (5–21) of pharyngitis and rhinitis in the exposed group. This risk increased with longer duration of employment and a history of rhinosinusitis. Additionally, the mean concentration of SO_2 pollutants was higher in exposed workplaces compared with administrative areas.

INTRODUCTION

Cement dust exposure causes harmful inflammatory responses (Ahmad et al., 2021). Exposure to cement dust has been associated with deleterious health effects in humans (Nkhama et al., 2015). Chronic exposure to Portland cement dust has been reported to be associated with symptoms such as stuffy nose, running nose, allergic rhinitis, and epistaxis among exposed groups (Manjula et al., 2013).

Air pollutants from cement plants include particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), volatile organic compounds, ozone (O_3), hydrogen sulfide (H_2S), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F), and polychlorinated biphenyls (PCBs). It has been shown that PM emissions account for 20–30%, which constitutes 40% of total industrial emissions (Gupta et al., 2012; Mehraj et al., 2013; Karagulian et al., 2015; Sánchez-Soberón et al., 2015).

The raw materials used in cement production contain various concentrations of trace elements such as cadmium (Cd), copper (Cu), zinc (Zn), nickel (Ni), cobalt (Co), and lead (Pb), as well as respirable silica (Si), arsenic (As), and chromium (Cr) VI. These elements determine the likelihood of health risks among cement workers (Singh & Pandey, 2011; Achternbosch et al., 2005). While respiratory effects are well-documented, fewer studies have examined ENT-specific pathologies, despite nasal and throat irritation being common complaints among workers. Boek et al. (2002) reported that exposure to toxic trace elements such as As, Ni, and Cd damages the epithelium of the ciliary mucosa, thereby impairing mucociliary transport. The presence of quartz in the raw materials of cement dust may also contribute to the development of adverse respiratory effects (Merenu et al., 2007).

To the best of our knowledge, there has been no previous study of ENT symptoms and diagnoses in Congolese cement workers. In addition, no official or national register has yet described the social (remuneration, benefits and profit-sharing, access to information), psychological (work stress and job security), environmental (hygiene factors, health and safety), organisational (employment contract, workload, accountability, working hours, and organisational culture), and physical (check-ups and work-life balance) working conditions of these workers and their workplace.

Most studies are limited to assessing the effects of the chemical environment, i.e., the effects of chemical air pollution on health. This study has the merit of assessing not only certain aspects of working conditions, such as duration of employment and hygiene factors, but also the effects of chemical pollution on health, as well as the effects of physical pollution (noise, vibrations) during cement production on ENT health by audiometry. The present study investigated whether cement workers performing different tasks and exposed to different levels of cement dust were associated with the prevalence of ENT symptoms and diagnoses in CIMKO, Kongo Central Province, Democratic Republic of the Congo (DRC).

METHODS

Study Design

This cross-sectional study was conducted between July and August 2024 among cement workers at the CIMKO Portland factory in Kimpese, Congo Central Province.

Study Sites

CIMKO is located in the town of Kimpese, territory of Songololo, province of Kongo Central, Democratic Republic of the Congo (DRC). The cement plant was selected based on its proximity to Kinshasa, availability and cooperation of workers, continuous production activities for at least two years prior to the study, and acceptance by the authorities and workers to participate.

Study Population

The sample size was calculated based on the prevalence of rhinitis (80.1%) reported in the cement industry in Haut Katanga province (Ngombe et al., 2019). Using the prevalence from Ngombe et al. (2019) is justified as the study context is similar (same country, cement workers, and the same outcome).

Inclusion Criteria

All full-shift workers (day or night shifts) aged 18 years or older who had worked for at least one year prior to the survey were recruited.

Exclusion Criteria

Participants with a documented history of ear, nose, and throat (ENT) pathology diagnosed by a physician prior to employment at the cement plant were excluded, as such a history could influence the results.

Sampling Technique and Sample Size Formula

A non-probability convenience sampling technique was used due to its simplicity and to reduce time constraints and resource limitations. Workers who met the inclusion criteria were included. The sample size formula used was:

$n = Z^2_{1-\alpha/2} \times p(1-p)/ e^2$

where:

- n = sample size
- z = standard normal variate (1.96 at 5% type I error)
- p = expected proportion based on previous studies
- e = tolerated margin of error

Using the prevalence reported by Ngombe et al. (2019), $n=(1.96)^2\times0.801\times(1-0.801)/(0.05)^2$. The tolerated margin of error was set at 5%. The minimum required sample size was 245; a larger sample size was preferred to reduce error margin and increase representativeness.

Definition of Exposure and Classification of Groups

Four indices—probability, frequency, intensity, and presence of peak—are used to assess exposure to cement dust (Delabre et al., 2010). This study classified exposure based on frequency (tasks most exposed to dust during working time). The exposed group included production (crushers, raw mills, calcination kilns, cement packaging), maintenance, transport, and handling workers, whereas the less exposed group included administrative staff and laboratory technicians.

Three workers with a history of ENT disease were excluded from the final analysis. The final sample comprised 302 workers: 270 in the exposed group and 32 in the less exposed group.

Data Collection

Written informed consent was obtained after a detailed explanation of the study purpose. A pre-designed questionnaire covering ENT symptoms and diagnoses, socio-demographic, clinical, and anthropometric variables was administered anonymously with the assistance of four physician investigators.

To minimise missing data:

- Only participants who consented were included.
- The study protocol was explained to participants and investigators.
- Investigators underwent a training session.
- A pilot study with 10 cement workers ensured questionnaire clarity; pilot data were excluded from final analysis.

Variables of Interest

- Dependent variable: ENT symptoms or diagnoses
- Independent variables: Sociodemographic and clinical variables (age, sex, residence, smoking status, education, socioeconomic level, exposure level, employment duration, marital status, religion) and anthropometric variables (height, weight, BMI, chest, waist, and hip circumferences).

ENT Examination

Otoscopy, anterior rhinoscopy, oropharyngeal examination, and Liminal Tone Audiometric Test (LTA) were performed twice daily (08:00–12:00 and 13:00–16:00) for groups of 20 to 25 workers using appropriate equipment. The principal investigator explained procedures beforehand.

The examination protocol included:

- Otoscopy: Visualisation of the external auditory canal, tympanic membrane, and tympanic cavity (if perforated) using a frontal light or battery-powered otoscope.
- Anterior rhinoscopy: Examination of nasal vestibule and cavities using frontal light and Killian nasal speculum.
- Oropharyngeal examination: Visualisation of posterior tongue, soft palate, palatine tonsils, and posterior pharyngeal wall using frontal light and disposable tongue depressor.

Audiometric Data

LTA was conducted with an automated screening audiometer (SHOEBOX, Ottawa, Canada) equipped with Radio Ear DD450 headphones (Minnesota, USA), testing

frequencies from 500 to 8000 Hz and intensities from −10 to 130 dB, validated by Canadian guidelines.

LTA Test Procedure

The principal investigator explained the test procedure. The test was performed in a quiet room with the investigator behind the seated participant, who wore headphones (red on right ear, blue on left). Participants were instructed to raise their hand immediately upon hearing any sound and lower it if none was heard. Results were recorded as audiograms.

Definition and Diagnosis of Occupational Rhinitis and Pharyngitis

ENT diagnoses include otological, rhinological, and laryngological conditions affecting the ear, nose, and throat.

- Rhinitis is inflammation of the nasal epithelium characterised by at least two nasal symptoms (rhinorrhoea, congestion, sneezing, itching). Subtypes include allergic rhinitis, infectious rhinitis, and non-allergic non-infectious rhinitis (Roberts et al., 2013). Some forms, such as vasomotor or atrophic rhinitis, may lack predominant inflammation (Wallace et al., 2008).
- Occupational rhinitis (OR) is inflammation with intermittent or persistent symptoms caused by workplace exposures, excluding stimuli outside the workplace. OR can present allergic, non-allergic, irritant, or neurogenic phenotypes (Rhinitis, 2008; Wallace et al., 2008).
- Chronic rhinosinusitis is defined by ≥8–12 weeks of symptoms including nasal blockage, discharge, facial pain/pressure, and/or reduced smell (Bachert et al., 2014).
- Acute pharyngitis is characterised by sore throat, fever, and pharyngeal inflammation with erythema and edema; exudates, vesicles, or ulcerations may also occur (Alcaide & Bisno, 2007).

Cement Dust Measurements

Nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM) are pollutants from fossil and biomass burning causing respiratory irritation and bronchitis (Liu et al., 2017). Due to equipment scarcity and time constraints, PM was not measured, and sampling was limited to two areas: high-exposure production/maintenance sections and a low-exposure secretary's office.

NO_2 and SO_2 were measured hourly using Alert Extreme GAXT-D-DL 2313 and GAXT-S-DL 0515 single-gas detectors (BW Technologies, USA). Area averages were compared to standard limits.

Checklist

Use of respirators was observed during morning (8:30–9:30) and afternoon (15:30–16:00) checks. Most exposed workers wore personal respiratory masks during these times.

Ethics Statement

The study complied with international bioethical standards, including the Declaration of Helsinki, and was approved by the Ethics Committee of the University of Kinshasa (ESP/CE/288/2024.T).

Informed Consent

All participants provided informed consent before participation.

Covariates

Potential confounders included age, BMI, education, smoking status, length of employment, medical history, and allergic history, obtained via structured questionnaire.

Statistical Analysis

Chi-square and Student's t-tests were used to compare categorical and continuous variables, respectively. Results were presented in tables and graphs; categorical variables as percentages and continuous variables as means ± standard deviations. Multiple logistic regression assessed associations between occupational tasks (predictors) and ENT symptoms/diagnoses (outcomes), adjusting for confounders. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were reported. Statistical significance was set at $p < 0.05$. Analyses were conducted using SPSS version 26.0.

RESULTS

A total of 302 subjects participated in this study (32 in the less exposed group and 270 in the exposed group). Baseline characteristics of the study population are shown in Table 1. The exposed group was slightly younger than

the less exposed group, with a mean age of 48.0 (SD = 10.4) years versus 51.8 (SD = 0.1) years, respectively.

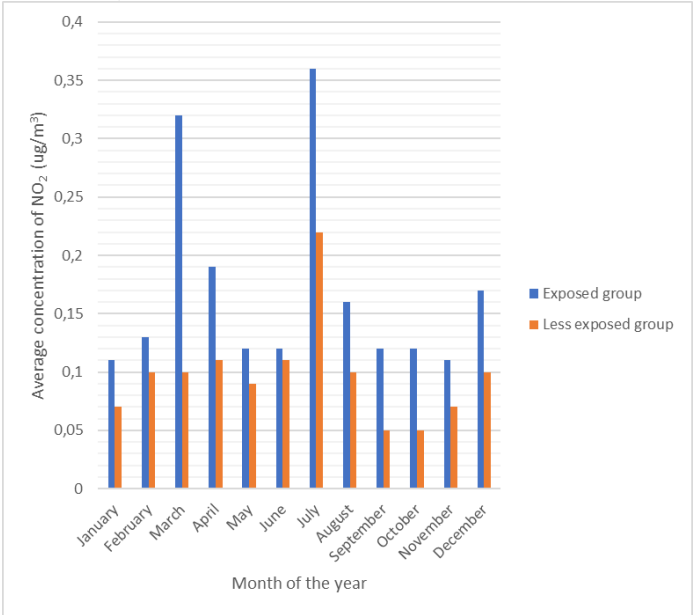
Table 1:
General Characteristics of the Study Population

ENT Conditions	Total *n*=302	Less exposed *n*=32	Exposed group *n*=270
Age (years) Mean (SD)	302	42.3 (5.64)	39.5 (8.26)
BMI (kg/m^2) Mean (SD)	302	23.8 (3.16)	22.9 (7.12)
DBP (mmHg) Mean (SD)	302	132.7 (15.22)	135.2 (13.17)
SBP (mmHg) Mean (SD	302	78.3 (11.19)	87.9 (18.12) *
Smoking status n (%)			
Current	106	9 (2.98)	97 (32.11) **
Former	19	3 (0.99)	16 (5.29)
Never	177	23 (7.61)	157 (51.98)
Allergy History			
Pollen	26	2 (0.66)	24 (7.94)
Food	4	2 (0.66)	2 (0.66)
Drug or medicine	6	4 (1.32)	2 (0.66)
Education level			
Elementary School	-	-	-
High School	252	11(3.64)	241 (99.80)*
University	50	21(6.95)	29 (9.60)
Length of employment			
(< 2 years)	155	9 (2.98)	146 (48.34) **
(≥ 2 years)	147	23 (7.61)	124 (41.06) **
Medical History			
HTA	22	5 (1.65)	17 (5.62) **
Asthma	1	-	1 (0.33)
Diabetes	6	1 (0.33)	5 (1.65) *

*p < 0.05, **p < 0.01 (Author, Year).

Figure 1 shows that the annual average concentration of NO_2 in the exposed and less exposed groups did not exceed the NIOSH occupational exposure limit (OEL) threshold limit value (TLV) of 0.36 µg/m³ for the exposed group and 0.22 µg/m³ for the less exposed group during our study period in July. The same trends were observed in August, with concentrations of 4.54 µg/m³ for the exposed group and 3.12 µg/m³ for the less exposed group.

Figure 1:
Annual average of NO_2 concentration in workplaces.



Note: NIOSH = National Institute for Occupational Safety and Health; Occupational Exposure Limit (OEL) for NO_2 = 25 ppm or 5 µg/m³; GM = Geometric Mean; Exposed group = production, transportation, maintenance, and handling workers; Less exposed group = administrative staff and laboratory technicians.

Figure 2 shows that the annual average concentration of SO_2 was higher in the exposed group and exceeded the TLV of the OEL adopted by NIOSH, with 15.54 µg/m³ for the exposed group and 5.87 µg/m³ for the less exposed group during July. A declining trend was observed in August, with concentrations of 4.54 µg/m³ for the exposed group and 3.12 µg/m³ for the less exposed group.

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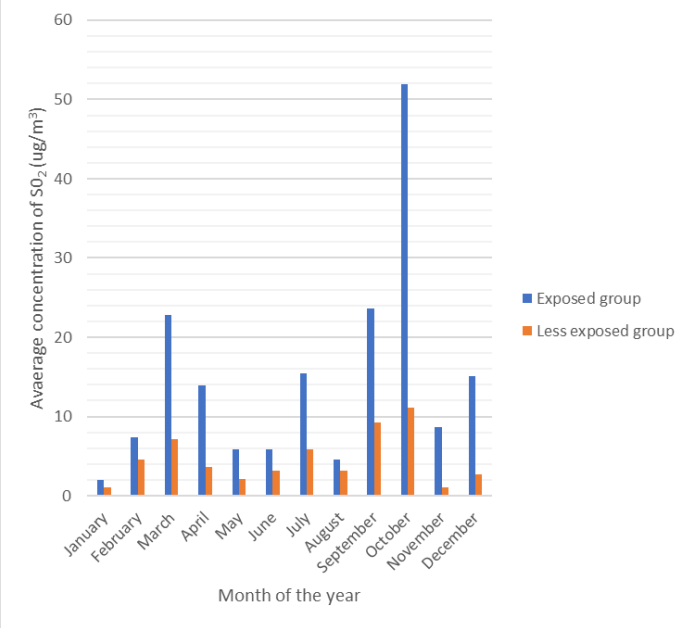
Figure 2:
Annual average of SO_2 concentration in workplaces.



Note: NIOSH = National Institute for Occupational Safety and Health; OEL for SO_2 = 5 ppm or 13 µg/m³; GM = Geometric Mean; Exposed group = production, transportation, maintenance, and handling workers; Less exposed group = administrative staff and laboratory technicians.

Table 2 shows the prevalence of ENT symptoms and diagnoses in the study population. Although not statistically significant, most ENT manifestations were more common in the exposed group than in the less exposed group. Additionally, the exposed group had significantly more pharyngitis (33.8% vs. 2.3%, p < .001) and rhinitis (53.6% vs. 11.9%, p = .001) compared to the less exposed group.

Table 2:
Prevalence of ENT Symptoms and Diagnoses Among the Study Population

ENT Conditions	Total *n=302*	Less exposed *n=32*	Exposed group *n=270*
ENT symptoms			
Sneeze	83	19 (6.29)	64 (21.19)
Rhinorrhea	64	15 (4.97)	49 (16.23)
Nasal obstruction	59	15 (4.97)	44 (14.57)
Headache	59	15 (4.97)	44 (14.57)
Itchy throat	31	5 (1.67)	26 (8.61)
Dry throat	30	4 (1.32)	26 (8.61)
Cough	30	4 (1.32)	26 (8.61)
Itchy nose	27	5 (1.67)	22 (7.28)
Tinnitus	20	3 (0.99)	17 (5.63)
Hearing loss	19	4 (1.32)	15 (4.97)
Nasal pain	16	3 (0.99)	13 (4.30)
Dizziness	11	2 (0.66)	9 (2.98)
Dysphonia	7	1 (0.33)	6 (1.99)
Dysosmia	5	3 (0.99)	2 (0.66)
Earache	5	-	5 (1.67)
Dysphagia	5	1 (0.33)	4 (1.3)
Dyspnea	2	-	2 (0.66)
Otorrhea	1	-	1 (0.33)
ENT diagnoses			
Chronic otitis media	14	5 (1.67)	9 (2.98)
Pharyngitis	109	7 (2.32)	102 (33.77) ***
Earwax plug	12	3 (0.99)	9 (2.98)
Rhinitis	198	36 (11.92)	162 (53.64) **
Laryngitis	4	-	4 (1.32)

*p < 0.05, **p < 0.01, ***p < 0.001 (Author, Year).

Table 3 presents the prevalence of pharyngitis and rhinitis among workers with a history of ENT disease. Cement workers with ≥ 2 years of employment had a higher prevalence of pharyngitis (28.8%) and rhinitis (34.44%) compared with those with < 2 years of employment, who had a prevalence of 7.28% for pharyngitis and 31.12% for rhinitis.

Table 3:
Prevalence of Pharyngitis and Rhinitis Among Workers with ENT Medical History *(n = 302)*

Medical History and tenure	Total n=302	Pharyngitis		Rhinitis	
ENT Medical History	n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)
Tonsillitis	9 (2.98)	6 (1.98) **	3 (0.99)	7 (2.32) **	2 (0.66)
Otitis	13 (4.30)	8 (2.65)	5 (1.65)	7 (2.32)	6 (1.99)
Laryngitis	4 (1.32)	1 (0.33)	3 (0.99)	1 (0.33)	3 (0.99)
Goitre	1 (0.33)	1 (0.33)	-	1 (0.33)	-
Rhinosinusitis	33 (10.93)	21 (6.95) *	12 (3.97)	23 (7.61) **	10 (3.31)
Tuberculosis	10 (3.31)	8 (2.65)	2 (0.66)	5 (1.65)	5 (1.65)
Dental infection	53 (17.55)	35 (11.59)	18 (5.96)	23 (7.62)	30 (9.93)*
Hyperactivity to odors	26 (8.61)	17 (5.63)	9 (2.98)	11 (3.64)	15 (4.97)
Allergy	27 (8.94)	19 (6.29)	8 (2.65)	11 (3.64)	16 (5.30)
Medical History					
HTA	22 (7.28)	15 (4.97)	7 (2.32)	13 (4.30)	9 (2.98)
Diabetes	1 (0.33)	1 (0.33)	-	-	1 (0.33)
Asthma	6 (1.97)	6 (1.97)	-	2 (0.66)	4 (1.32)
Length of employment					
(< 2 years)	155 (51.32)	22 (7.28)	133 (44.03) **	94 (31.12)	71 (23.51)
(≥ 2 years)	147 (45.37)	87 (28.80) *	60 (19.86)	104 (34.44) *	43 (14.24)

*p < 0.05, **p < 0.01

The odds ratios for the association between pharyngitis, rhinitis, and occupational groups are shown in Table 4. The exposed group had a more than sevenfold increased

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risk of pharyngitis (adjusted odds ratio [aOR] = 7.4, 95% CI [3.3, 16.8]) and a more than twofold increased risk of rhinitis (aOR = 2.4, 95% CI [1.4, 4.1]). In the total population, rhinosinusitis was associated with a more than twofold increased risk of developing pharyngitis (aOR = 2.5, 95% CI [1.6, 3.9]) and rhinitis (aOR = 2.7, 95% CI [1.2, 6.5]). Similarly, duration of employment ≥ 2 years increased the risk of pharyngitis by more than fivefold (aOR = 5.3, 95% CI [3.6, 15.2]) and rhinitis by more than threefold (aOR = 3.6, 95% CI [2.1, 5.8]).

Table 4:
Multivariate Analysis of the Association Between Pharyngitis, Rhinitis, Occupation Groups, and Medical History

Occupation and Medical history	Pharyngitis		Rhinitis	
	Crude model Model OR (95% CI)	Adjusted aOR (95% CI)	Crude model OR (95% CI)	Adjusted Model aOR (95% CI)
Less exposed group	1		1	
Exposed group [a]	3.7 (2.1;11.6) **	7.4 (3.3;16.8) ***	2.9 (1.3; 7.5) *	2.4 (1.4;4.1) *
Length of employment (< 2 years)	1		1	
Length of employment (≥ 2 years) [b]	1.5 (1.2;2.6) ***	5.3 (3.6;15.2) **	2.1 (1.6;3.5) *	3.6 (2.1;5.8) *
Length of time in post (<2 years)	1		1	
Length of time in post (>2 years)[c]	1.6 (2.3;2.9) *	1.3 (1.5; 1.9) *	1.9 (1.5;2.5) ***	4.9 (2.5;9.6) **
Smoking Status [d]				
Never Smoking	1		1	
Former smoking	1.3 (1.1;1.7)	1.1(0.9: 1.2)	1.6 (0.8;2.2)	1.2 (0.8;2.3)
Current Smoking	1.8 (2.3: 1.9)	1.5 (0.7: 2.1)	1.2 (1.6; 1.9).	2.1 (0.9;3.2)
Allergy History [e]				
Never allergy	1		1	
Pollen allergy	1.1 (0.8;1.4)	1.8 (0.9;3.2)	1.9 (2.1;3.1)	1.6 (0.7;2.3)
Food allergy			1.3 (1.9;2.7)	1.5 (0.9;1.9)
Drug allergy	1.4 (1.3;2.1)	1.4 (0.8;2.5)	1.7 (2.3;3.6)	1.2 (0.9;2.4)
	1.6 (0.9;2.4)	1.2 (0.9;1.7)		
Medical history				
Tonsillitis [f]	2.8 (1.7;4.8) *	4.3 (2.1;6.2) *	1.3 (1.1;2.3) *	5.7 (3.3;9.7) *
Rhinosinusitis [g]	2.4 (1.1;5.1) ***	2.5 (1.6;3.9) **	1.6 (1.3;2.1) **	2.7 (1.2;6.5) **

$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Notes:

- OR: Odds Ratio
- aOR: Adjusted Odds Ratio
- Exposed group: Production (crushers, raw mills, calcination kilns, cement packaging), maintenance, transport, and handling workers
- Less exposed group: Administrative staff and laboratory technicians

Adjustments:

a. adjusted for medical history, length of time in post, length of employment, smoking status, allergy history
b. adjusted for medical history, length of time in post, smoking status, allergy history
c. adjusted for medical history, length of employment, smoking status, allergy history
d. adjusted for medical history, length of employment, length of time in post, allergy history
e. adjusted for medical history, smoking status, length of time in post, length of employment
f. adjusted for rhinosinusitis, length of time in post, length of employment, smoking status, allergy history
g. adjusted for tonsillitis, length of time in post, length of employment, smoking status, allergy history

DISCUSSION

Our study investigated whether cement workers performing different tasks and exposed to varying levels of cement dust were associated with the prevalence of ENT symptoms and diagnoses in CIMKO, Kongo Central Province, DRC. The analysis revealed that the exposed group (production, maintenance, transport, and handling) had a higher prevalence of ENT symptoms and diagnoses than the less exposed group (administration, laboratory). These results could be attributed to the higher concentration of cement particles in the production area and inadequate personal protective equipment (e.g., inappropriate respiratory masks). Several studies have reported that cement manufacturing contributes to emissions of non-volatile metal dusts, including chromium (Cr), arsenic (As), nickel (Ni), aluminum (Al), and manganese (Mn) (Meo et al., 2008).

In addition, the inhalation of heavy metals can cause rhinitis, pharyngitis, laryngitis, and tracheal bronchitis, resulting in symptoms such as a stuffy nose and sore throat (Islam et al., 2015). Exposure to toxic trace elements such as As, Ni, and cadmium (Cd) damages the epithelium of the ciliary mucosa, thereby impairing mucociliary transport. Impaired mucociliary transport results in reduced clearance of inhaled metal particles from the nasal mucosa, leading to their absorption and further exacerbation of toxicity (Alekseenko et al., 2019).

The exposed group had a higher risk of developing pharyngitis and rhinitis compared to the less exposed group in the present study. These findings are likely due to the chemicals in cement, which can affect individual health and the environment. The exact role of sulfur

dioxide (SO_2) in allergic inflammation in allergic rhinitis (AR) remains unclear. However, several animal studies have established an allergic rhinitis mouse model with long-term SO_2 exposure. It was found that long-term SO_2 exposure increased nasal symptom scores, eosinophil infiltration, and Th1/2/17 inflammation in the nasal mucosa of house dust mite (HDM)-sensitized allergic mice. SO_2 caused structural alterations and dysfunction of mucociliary activity in guinea pig tracheas and enhanced airway hyperresponsiveness via IL-4 in ovalbumin-sensitized rats. Long-term SO_2 exposure exacerbated eosinophilic inflammation (Joelsson et al., 2020; Song et al., 2012; Ye et al., 2022; Zhang et al., 2021). In rhinitis, pharyngeal irritation has been attributed to lymphoid hypertrophy and prominence of adenoidal and tonsillar tissue, which results from chronic allergic inflammation of the upper airway (Ja, 2006).

The study by Kamaludin et al. (2020) showed that cement contains a variety of minerals that may pose significant health risks to workers, especially cement workers. Dust particles can settle and remain in the airways for extended periods before being expelled by breathing out or penetrating deep into the lungs, depending on the particle size fraction and method of removal (Martin et al., 2014). Similar results to those in our study were reported by Cha et al. (2011), who found that adverse clinical health effects such as asthma, rhinitis, and dermatitis were more common in the cement dust-exposed group than in the less exposed group. Urinary chromium and mercury levels were significantly higher in the exposed group than in the less exposed group (Cha et al., 2011). Mohamed-Hussein et al. (2019) reported that allergic conjunctivitis was the most common condition among workers (26.7%), followed by allergic rhinitis (20.9%). We would like to emphasize that during the writing of this manuscript, no conflicting results were found in the various search platforms used; however, this does not imply that none exist.

The levels of SO_2 measured at the workplaces of the group most exposed to cement dust in the current study were above the occupational exposure limit value (OEL). These results could be attributed to outdated technology, the use of pneumatic processes for cleaning activities, and the lack of local exhaust ventilation in the production area.

Additionally, length of employment and a history of rhinosinusitis and tonsillitis were associated with an increased risk of pharyngitis and rhinitis. We support the hypothesis that prolonged and repeated exposure to cement dust may cause adverse effects on the skin, eyes, upper and lower respiratory tracts, and hematological system, depending on the duration and sensitivity of workers exposed to cement dust. Occupational rhinitis may be allergic or non-allergic, with the former almost always preceding or developing simultaneously with occupational asthma (Scadding, 2009).

Strengths and Limitations

This study is the first to elucidate the association between cement dust exposure and ENT symptoms and diagnoses in CIMKO workers in Kongo Central Province, DRC. Otoscopy, anterior rhinoscopy, oropharyngeal examination, and Liminal Tone Audiometric Test (LTA) were performed to assess the ENT sphere. Ambient pollution parameters, including NO_2 ($\mu g/m^3$) and SO_2 ($\mu g/m^3$), were measured. Cement dust measurements were conducted in different work areas of the plants to document different levels of exposure to cement dust. However, measurement bias cannot be excluded.

Despite these strengths, the study has several limitations. First, as a cross-sectional study, it cannot establish a direct causal relationship between exposure and the occurrence of ENT symptoms and diagnoses; a longitudinal study is needed for causal inference. Second, the cement dust measurements were carried out in selected sections using non-probability sampling techniques, limiting the generalizability of the results to other sections and populations with different working conditions. Establishing statistical references would help generalize the results. Third, the sample size was relatively small, which affects statistical power. Fourth, due to material limitations, we were unable to measure all inhalable and respirable dusts such as particulate matter (PM) and silica. Fifth, convenience sampling likely introduced sampling bias since participants were not randomly selected; clearly defining the target population, conducting a prior pilot study, formulating specific research questions, and employing appropriate statistical analyses can help minimize this bias. Sixth, participants were asked to recall information from memory, making the study susceptible

to recall bias. Use of open-ended questions encouraging authentic recall and an environment conducive to truthful responses have been shown to reduce recall bias.

CONCLUSION AND SUGGESTIONS

The study showed that the prevalence of ENT symptoms and diagnoses was higher in the group exposed to cement dust than in the less exposed group. Occupational exposure to cement dust was associated with ENT diagnoses; in particular, a higher risk of pharyngitis and rhinitis was observed in the exposed group, and this risk increased with duration of employment, history of rhinosinusitis, or tonsillitis. Furthermore, the mean concentrations of NO_2 and SO_2 pollutants were significantly higher in production, maintenance, transportation, and handling positions compared to the office.

It is strongly recommended to implement preventive measures and environmental monitoring to protect cement workers, especially those in the most exposed areas. Individual preventive measures such as wearing appropriate masks and regular screening for ENT diseases should be mandatory. Collective preventive measures, including machine maintenance, wet dust suppression during cleaning operations, and improvements to exhaust systems in the production area, are necessary standard operating procedures to reduce the risk of otorhinolaryngological pathologies.

Ethical Approval: Ethical clearance approval was obtained from the Ethics Committee of the University of Kinshasa, DRC (ESP/CE/288/2024.T).

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