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Risk Factors for Nasal Symptoms, Olfactory Disorders and Mucociliary Transport in Factory Workers

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ABSTRACT

Background: Occupational exposure to a variety of individual chemicals has been associated with olfactory dysfunction, which is important for many occupational groups that rely on intact olfactory function to perform their jobs and for their safety. We aim to determine the risk factors for nasal symptoms, olfactory disorders and mucociliary transport in spice factory workers in Semarang.

Subjects and Method: This was a cross-sectional study. A sample of 600 factory workers filled out the NOSE Scale and QOD-NS questionnaires, having their ears, nose, and throat examined, and calculated the time in which the participants tasted sweetness after being given saccharin to the inferior turbinate. The analysis used were univariate, bivariate and multivariate analysis.

Results: Of 600 respondents, 52.2% were women, 87.8% had reported no nassal symptoms, 81.5% had normal NOSE scale, and 83.3% had normal mucociliary transport. Risk factors for nasal disorders, smell disorders, and mucociliary transport disorders were age ≥40 years old, male, smoking, longer exposure time, obesity, and PPE use.

Conclusion: There is a significant association between occupational risk factors and nasal symptoms, olfactory disorders and mucociliary transport disorders. The most influential factor is discipline in using PPE to prevent nasal disorders, olfactory disorders and mucociliary transport disorders.

Keywords: Nasal symptoms, smell disorders, mucociliary transport, NOSE scale, QOD-NS

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BACKGROUND

Occupational rhinitis is an inflammatory process of the nasal mucosa related to work, where rhinitis symptoms develop in previously healthy individuals after exposure to agents at work and the rhinitis is exacerbated by their work (Liva et al., 2021).

Airway inflammation can be caused by occupational agents that fall into two categories: high molecular weight (HMW) agents and low molecular weight (LMW) agents (Malo & Chan-Yeung, 2007). Occupational rhinitis can be classified as allergic mediated by immunological exposure to sensitive high molecular weight (HMW > 5

kDa) proteins (HMW >5 kDa), or non-allergic mediated by non-immunological low molecular weight chemical stimuli (LMW <5 kDa) (Doty, 2015).

Cross-sectional studies of various works show varying prevalence rates of occupational rhinitis (3%-87%), although rates are higher for HMW agents compared to lower for LMW agents (Dostbil et al., 2011). A history of allergic rhinitis or asthma, baseline total IgE >150 kIU/L, or work with frequent exposure to animals have been shown to be risk factors for occupational rhinitis (Wise et al., 2023).

Symptoms of occupational rhinitis include nasal congestion, secretions, itching, sneezing, facial pressure, headaches, loss of sense of smell, formation of nasal crusts, dry nose, and nosebleeds caused by exposure to irritants in the workplace (Crivellaro et al., 2020). Theses symptoms should correlate with the workplace environment. Given the significant and financial impacts associated with an occupational rhinitis diagnosis, it is also important to employ objective methods to prevent patient misclassification (Kotz et al., 2021a). Since combining both are essential, we aim to evaluate the risk factors associated with objectively assessed nasal disorders, smell disorders, and mucociliary transport problems in occupational rhinitis.

SUBJECTS AND METHOD

1. Study Design

The study design is an observational cross-sectional study and is conducted in a spice factory in Jawa Tengah on July 2023. Factory workers were asked to fill in demographic questionnaires and underwent ear, nose, and throat examination. They were then classified on whether or not they have nasal disorders, smell disorders, and mucociliary transport problems. The data were then analyzed with bivariate and multivariate analysis.

2. Population and Sample

A total of 600 spice factory workers took part in ear, nose and throat examinations, the activity lasted for 6 days. The inclusion criteria are all workers aged 18-55 years and are willing to take part in the examination, while the exclusion criteria are workers who have a history of head trauma and suffer from nasal polyps or tumors. Participants completed a questionnaire on nasal olfactory symptoms as well as examination of the ears, nose, throat and mucociliary transport. The selection of research subjects was carried out using a convenient sampling method from all 600 workers who were examined.

3. Study Variables

Independent variables were gender, age, smoking history, exposure time, body mass index (BMI), diabetes mellitus, and discipline in wearing personal protective equipment (PPE). Dependent variables were nasal complaints, olfactory complaints, and mucociliary transport disorders.

4. Operational Definition of Variables

Definition operational variables of independent variables:

1. Gender: Biological distinction between male and female participants.
2. Age: Chronological age of the participants, typically measured in years.
3. Smoking History: Whether the participant has a history of smoking, including duration and frequency.
4. Exposure Time: The duration of exposure to specific environmental or occupational factors being studied.
5. BMI: A measure of body fat based on the participant's weight in kilograms divided by the square of height in meters (kg/m^2).

6. Diabetes Mellitus: A chronic metabolic disorder characterized by high blood glucose levels.
7. Discipline in Wearing Personal Protective Equipment (PPE): The consistency and adherence of participants to using PPE as required in their environment.

Definition operational variables of dependent variables:

1. Nasal Complaints: Reported symptoms or discomfort associated with the nasal cavity, such as blockage, pain, or discharge.
2. Olfactory Complaints: Concerns or symptoms related to the sense of smell, including reduced ability to detect or identify odors.
3. Mucociliary Transport Disorders: Abnormalities or inefficiencies in the mucociliary clearance mechanism, potentially leading to respiratory complications.

8. Study Instruments

The nasal complaints questionnaire uses The Nasal Obstruction Symptom Evaluation (NOSE Scale) in the form of questions regarding nasal symptoms such as a feeling of lump in the nose, blocked nose, difficulty breathing through the nose, difficulty sleeping due to a blocked nose, and the ability to breathe air through the nose when doing physical activity. Meanwhile, olfactory complaints use the questionnaire The Questionnaire of Olfactory Disorders – Negative Statements (QOD-NS), consisting of 17 statements which are rated on a scale of 0 to 3 and the total score ranges from 0 to 51. Mucociliary transport examination uses a saccharin test to measure the time starting from the time the saccharin is placed under the inferior turbinate until it feels sweet. Normal TMS time is 12-15 minutes (Valía et al., 2008).

9. Data analysis

The normality test is carried out to determine the distribution of independent variable data. Univariate analysis uses frequency distribution. The chi-square test is carried out to determine the relationship between categorical independent variables and cofounding variables on olfactory function. If a significance value of $p < 0.05$ is obtained, then proceed with the coefficient contingent correlation test and test. Multivariate with logistic regression to determine the magnitude of the influence between variables simultaneously.

10. Research Ethics

Research ethical issues including informed consent, anonymity, and confidentiality, were addressed carefully during the study process. The research ethical clearance approval letter was obtained from the Research Ethics Committee at Dr. Karyadi Hospital, Semarang, Indonesia, No. 1487/-EC/KEPK-RSDK/2023 on July 14, 2023.

RESULTS

1. Sample Characteristics

ENT health examination of workers was carried out for 6 days, the number of workers who took part in the examination was 600 people. Subject characteristics are listed in Table 1. See Table 1 for characteristics of research subjects.

Table 1. Characteristics of Research Subjects Risk Factors For Nasal Symptoms, Olfactory Disorders And Mucociliary Transport In Factory Workers

Variable	N (%)	Mean SD
Gender		
Man	287 (47.8)	1.52 (0.499)
Women	313 (52.2)	
Age		
> 40 years	132 (22.0)	1.15 (0.357)

Variable	N (%)	Mean SD
≤ 40 years	468 (78.0)	
Smoking History		
Smoke	89 (14.8)	1.15 (0.360)
Do not smoke	511 (85.2)	
Exposure Time		
≥ 10 years	269 (44.8)	1.53 (0.499)
< 10 years	331 (55.2)	
BMI		
Overweight : ≥25	92 (15.3)	1.15 (0.365)
Normal : <25	508 (84.7)	
Diabetes Mellitus		
No	543 (90.5)	1.936 (0.244)
Yes	57 (9.5)	
Discipline in wearing PPE		
Discipline	505 (84.2)	
Undiscipline	95 (15.8)	1.20 (0.406)
Nasal Symptoms		
No Symptoms	527 (87.8)	1.10 (0.300)
There are symptoms	73 (12.2)	
Smell disorders		
Score >12.5 Impaired	111 (18.5)	1.16 (0.372)
Score ≤12.5 Normal	489 (81.5)	
Mucociliary Transport		
Normal	500 (83.3)	1.14 (0.352)
Abnormal	100 (16.7)	

A total of 600 workers who underwent Ear-Nose-Throat (ENT) heath checks consisted of 278 workers (47.8%) male and 313 workers (52.2%) female. The largest age group is the 21-30 year age group with 215 people (%), followed by the 41-50 year age group with 108 people (%). Meanwhile, the smallest age group is the age group <20 years with 8 people (%). The BMI range was 18.5-24.9 (normal) for 508 people (84.7%), BMI 25-29.9 (overweight) for 80 people (13%), BMI >30 (obese) for 12 people (2%). 527 (87.8%) workers did not experience smell problems and 73 (12.2%) had a range of smell problems 0-51 with a mean score of 11.5. The TMS time range was 1-480 seconds with an average of 12.9 seconds.

From Table 2, there are 5 characteristic symptoms of nasal disorders consisting of a stuffy nose, congestion, difficulty breathing, having difficulty sleeping due to a blocked nose and not being able to breathe in enough air through the nose when doing physical activity. The results of the study showed that out of 579 workers, 14 workers (2.42%) had a blocked nose, 32 workers had a blocked nose (5.53%), 33 workers had difficulty breathing (5.570%), 37 workers had difficulty sleeping (6.39%) and unable to breathe enough air when doing physical work as many as 24 workers (4.32%). See Table 2 for nasal symptoms with the NOSE scale questionnaire.

Table 2. Nasal Symptoms with the NOSE Scale questionnaire

No	Question	Yes N (%)	No N (%)
1	Do you currently feel like there is a lump in your nose?	14 (2.42)	565 (97.58)

No	Question	Yes N (%)	No N (%)
2	Do you currently feel a blocked nose?	32 (5.53)	547 (94.47)
3	Do you currently have difficulty breathing through your nose?	33 (5.70)	546 (94.30)
4	Are you currently having difficulty sleeping due to a blocked nose?	37 (6.39)	542 (93.61)
5	Do you currently feel unable to breathe in enough air through your nose when doing physical activity?	25 (4.32)	554 (95.68)

2. Bivariate Analysis

Risk factors for nasal symptoms include age, gender, smoking history, length of exposure, Body Mass Index (BMI), Diabetes Mellitus (DM), and discipline in using PPE when working. Based on the Table 3, it shows that most of the 468 workers aged less then 40 years did not have symptoms of nasal problems, namely 439 (93.8%) workers and 29 (6.2%) workers had nasal problems. Of the 132 workers aged over 40 years, the majority of workers did not experience symptoms of nasal problems, namely 88 (66.7%) workers, the remaining 44 workers (33.3%) experienced symptoms of nasal disorders. The Chi-square test shows that there is a relationship between age and symptoms of nasal disorders with a p <0.001, workers aged over 40 years have a risk level of 7.5 times experiencing nasal disorders. See Table 3 for risk factors for nasal disorders.

Table 3. Risk Factors for Nasal Disorders

Variable	Nasal Disorders		Total	OR	95% CI	p
	No Symptoms	Symptoms				
	N (%)	N (%)	N (%)			
Age						
< 40 years	439 (93.8)	29 (6.2)	468	7.5	7.2-7.9	<0.001
≥ 40 years	88 (66.7)	44 (33.3)	132			
Gender						
Man	264 (92)	23 (8.0)	287	2.1	1.5-3.2	0.003
Female	263 (84.0)	50 (16.0)	313			
Smoking						
Do not smoke	457 (89.4)	54 (10.6)	511	2.2	1.5-3.8	0.004
Smoke	70 (78.7)	19 (21.3)	89			
Exposure Time						
< 10 years	300 (90.6)	31 (9.4)	331	1.7	0.8-3.6	0.020
≥ 10 years	227 (84.4)	42 (15.6)	269			
BMI						
Normal	496 (97.6)	12 (2.4)	508	81.3	72.3-84.7	<0.001
Obesity	31 (33.7)	61 (66.3)	92			
Diabetes Mellitus						
Yes	48 (84.2)	9 (15.8)	57	0.7	0.2-4.2	0.379
No	479 (88.2)	64 (11.8)	543			
Wearing PPE						
Yes	500 (99.0)	5 (1.0)	505	251.8	250.1-256.8	<0.001
No	27 (28.4)	68 (71.6)	95			

Of the 287 male workers, the majority did not have symptoms of nasal disorders, namely 264 (92%) workers and 29 (6.2 %) workers experienced symptoms of nasal disorders. Of the 313 female workers, the majority did not have symptoms of nasal disorders, namely 263 984%) workers and 50 (16%) workers experienced symptoms of nasal disorders. The Chi-square test shows that there is a relationship between age and symptoms of nasal disorders with a p= 0.003, female workers are 2.1 times more likely to experience nasal disorders.

Of the 511 workers who had no history or were still smoking, the majority did not have symptoms of nasal disorders, namely 457 (89.4%) workers and only 54 (10.6%) workers experienced symptoms of nasal disorders. Of the 89 workers who had a history of or were still smoking, most of them did not have symptoms of nasal problems, namely 70 (78.7%) workers and 19 (21.3%) workers experienced nasal problems. The Chi square test shows that there is a relationship between a history of smoking and nasal disorders with a p= 0.004, workers who have a history or are still smoking have a 2.2 times risk of experiencing symptoms of nasal disorders.

Of the 331 workers with exposure for less than 10 years, the majority did not have symptoms of nasal disorders, namely 300 workers (90.6%) and 31 workers (9.4%) experienced symptoms of nasal disorders. Of the 269 workers with exposure for more than 10 years, the majority did not have symptoms of nasal disorders, namely 227 workers (84.4%) and 42 workers (15.6%) experienced symptoms of nasal disorders. The chi-square test shows that there is a relationship between the length of exposure to nasal disorders with p <0.001, workers who are exposed for more than 10 years have a 1.7 times risk of experiencing symptoms of nasal disorders.

Of the 508 workers with a normal Body Mass Index, the majority did not have symptoms of nasal disorders, namely 408 (97.6%) workers and 12 (2.45) workers experienced symptoms of nasal disorders. Of the 92 workers with an obesity Body Mass Index, the majority had symptoms of nasal disorders, namely 61 (66.35) workers and 31 (33.7%) workers did not experience symptoms of nasal disorders. The chi-square test shows that there is a relationship between Body Mass Index and symptoms of nasal disorders with a p <0.001, workers who have an obese Body Mass Index are 81.3 times more likely to experience symptoms of nasal disorders.

Of the 57 workers with diabetes mellitus (DM), the majority did not have symptoms of nasal disorder, namely 48 workers (84.2%) and 9 workers (15.8%) experienced symptoms of nasal disorders. Of the 543 workers who did not have diabetes mellitus (DM), the majority did not have symptoms of nasal disorders, namely 479 workers (88.2%) and 64 workers (11.8%) experienced symptoms of nasal disorders. The chi square test shows that there is a relationship between diabetes mellitus and symptoms of nasal disorders with p= 0.379. Workers who have diabetes mellitus have a 0.7 times risk of experiencing nasal disorders.

Of the 505 workers with good discipline in using PPE, the majority did not have symptoms of nasal problems, namely 505 workers (99%) and 5 workers (1%) experienced symptoms of nasal problems. Of the 95 workers with poor discipline in using PPE, the majority had symptoms of nasal problems, namely 68 workers (71.6%) and 27 workers (28.4%) did not experience symptoms of nasal disorders. The Chi-square test shows that there is a relationship between diabetes mellitus and nasal disorders with p <0.001. Workers who are

not disciplined in using PPE are 251.8 times more likely to experience symptoms of nasal disorders.

Risk factors for smell disorders consist of age, gender, smoking history, length of exposure, Body Mass Index (BMI), Diabetes Mellitus (DM) and discipline in using PPE when working. Based on the Table 4, it shows that of the 468 workers ages less than 40 years, the majority did not have smell problems, namely 426 workers (91%) and only 42 workers (9%) and smell problems. Of the 132 workers aged overs 40 years, the majority of workers experienced symptoms of nasal problems, namely 69 workers (52.3%), and 63 workers (47.7%) experienced symptoms of nasal disorders. The Chi square test shows that there is a relationship between age and symptoms of olfactory disorders with p <0.001. Workers aged over 40 years also have a risk level of 11 times experiencing olfactory disorders. See Table 4 for risk factors for smell disorders.

Table 4. Risk factors for smell disorders

Variabel	Smell Disorders		Total	OR	95% CI	P
	Normal	Disorders				
	N (%)	N (%)	N (%)			
Age						
< 40 Years	426 (91.0)	42 (9.0)	468 %)	11.1	10.5-11.6	<0.001
≥ 40 Years	63 (47.7)	69 (52.3)	132			
Gender						
Male	247 (86.1)	40 (13.9)	287	1.8	0.7-3.5	0.006
Female	242 (77.3)	71 (22.7)	313			
Smoking History						
Do not smoke	430 (84.1)	81 (15.9)	511	2.6	1.8-5.6	<0.001
Smoke	59 (66.3)	30 (33.7)	89			
Exposure Time						
< 10 Years	281 (84.9)	50 (15.1)	331	1.6	1.2-4.4	0.018
≥ 10 Years	208 (77.3)	61 (22.7)	269			
Body Mass Indeks						
Normal	466 (91.7)	42 (8.3)	508	33.2	30.5-	<0.001
Obesity	23 (25.0)	69 (75.0)	92		38.4	
Diabetes Mellitus						
No	449 (82.7)	94 (17.3)	543	0.4	0.1-4.5	0.021
Yes	40 (70.2)	17 (39.8)	57			
PPE use						
Yes	468 (92.7)	37 (7.3)	505	44.5	40.5-51.6	<0.001
No	21 (22.1)	74 (77.9)	95			

Of the 287 male workers, the majority did not have olfactory disorders, namely 247 workers (96.1%) and 40 workers (13.9%) experienced symptoms of nasal disorders. Of the 313 female workers, the majority did not have olfactory disorders, namely 242 workers (77.3%) and 71 workers (22.7%) experienced symptoms of nasal disorders. The Chi Square test shows that there is a relationship between age and smell disorders with p= 0.006, female workers are 1.8 times more likely to experience smell disorders.

Of the 511 workers who had no history or were still smoking, the majority did not have smell problems, namely 430 workers (84.1%) and 81 workers (15.9%) had smell problems. Of the 89 workers (66.3%) and 30 workers (33.7%) had smell problems. The Chi square test shows that there is a

relationship between smoking history and nasal disorders with p <0.001, workers who have a history or are still smoking have a 2.6 times risk of experiencing smell disorders.

Of the 331 workers with exposure for less than 10 years, the majority did not have smell problems, namely 281 workers (84.9%) and 50 workers (15.1%) had smell problems. Of the 269 workers with exposure for more than 10 years, the majority did not have smell problems, namely 208 workers (77.3%) and 61 workers (22.7%) had smell problems. The Chi square test shows that there is a relationship between the length of exposure to smell disorders with p= 0.018, workers who are exposed for more than 10 years have a 1.6 times risk of experiencing smell disorders.

Of the 508 workers with a normal Body Mass Index, the majority did not have smell problems, namely 446 workers (91.7%) and 42 workers (8.3%) workers had smell problems. Of the 92 workers with an obesity Mass index, the majority had olfactory disorders, namely 69 workers (75%) and 23 workers (25%) did not experience olfactory disorders. The chi square test shows that there is a relationship between the Body Mass Index and olfactory disorders with p <0.001, workers who have an obese Body Mass Index are 33.2 times more likely to experience olfactory disorders.

Of the 543 workers who did not have diabetes mellitus (DM), the majority did not experience smell problems, namely 449 workes (82.7%) and 94 workers (17.3%) had smell problems. Of the 57 workers with diabetes mellitus (DM), the majority did not have smell problems, namely 40 workers (70.2%) and 17 workers (39.8%) did not have smell problems. The Chi square test shows that there is a relationship between diabetes mellitus and smell disorders with p= 0.021, workers who have diabetes mellitus have a 0.4 times risk of experiencing smell disorders.

Of the 505 workers who were disciplined in using PPE, the majority did not have smell problems, namely 468 workers (92.7%) and 37 workers (7.3%) had smell problems. Of the 95 workers with poor discipline in using PPE, the majority had symptoms of nasal problems, namely 74 workers (77.9%) and 21 workers (22.1%) did not experience symptoms of nasal disorders. The Chi Square test shows that there is a relationship between discipline in using PPE and smell disorders with p <0.001, workers who are not disciplined in using PPE have a 44.5 times risk of experiencing smell disorders.

Risk factors for mucociliary transport disorders consist of age, gender, smoking history, length of exposure, Body Mass Index (BMI), Diabetes Mellitus (DM) and discipline in using PPE while working. Based on the Table 5, it shows that of the 468 workers aged less than 40 years, the majority did not have mucociliary transport disorders, namely 428 workers (91.5%) and 40 workers (8.5%) had mucociliary transport disorders. Of the 132 workers aged over 40 years, the majority of workers did not experience mucociliary transport disorders, namely 72 workers (54.5%) and 60 workers (45.5%) experienced mucociliary transport disorders. The Chi Square test shows that there is a relationship between age and mucociliary transport with p <0.001, workers aged over 40 years also have a risk level of 8.9 times experiencing mucociliary transport. See Table 5 for risk factors for smell disorders.

Table 5. Risk factors for mucociliary transport disorders

Variable	Mucociliary Transport		Total	OR	95% CI	p
	Normal	Abnormal				
	N (%)	N (%)	N (%)			
Age						
< 40 Years	428 (91.5)	40 (8.5)	468	8.9	7.6-9.4	0.000
≥ 40 Years	72 (54.5)	60 (45.5)	132			
Gender						
Male	257 (89.5)	30 (10.5)	287	2.4	1.2-3.9	0.000
Female	243 (77.6)	70 (22.4)	313			
Smoking history						
Do not smoke	434 (84.9)	77 (15.1)	511	1.9	0.5-2.7	0.012
Smoke	66 (74.2)	23 (25.8)	89			
Exposure Time						
< 10 Years	282 (85.2)	49 (14.8)	331	1.3	0.2-5.3	0.174
≥ 10 Years	218 (81.0)	51 (19)	269			
BMI)						
Normal	480 (94.5)	28 (5.5)	508	61.7	53.5-72.6	0.000
Obesity	20 (21.7)	72 (78.3)	92			
DM						
No	455 (83.8)	88 (16.2)	543	0.7	0.12-4.38	0.350
Yes	45 (78.9)	12 (21.1)	57			
PPE use						
Yes	487 (96.4)	18 (3.6)	505	292.72	280.12-298.6	0.000
No	13 (13.7)	82 (86.3)	95			

Of the 282 male workers, the majority did not have mucociliary transport disorders, namely 247 workers (87.6%) and only 35 workers (12.4%) had mucociliary transport disorders. Of the 297 female workers, the majority did not have mucociliary transport disorders, namely 246 workers (82.8%) and 51 workers (17.2%) had mucociliary transport disorders. The Chi Square test shows that there is no relationship between age and mucociliary transport disorders with p= 0.107, female workers are 1.36 times more likely to experience mucociliary transport disorders.

Of the 511 workers who had no history or were still smoking, the majority did not have mucociliary transport disorders, namely 434 workers (84.9%) and only 77 workers (15.1%) had mucociliary transport disorders. Of the 89 workers who had a history of or were still smoking, most of them did not have mucociliary transport disorders, namely 66 workers (74.2%) and 23 workers (25.8%) had mucociliary transport disorders. The Chi Square test shows that there is a relationship between smoking and mucociliary transport disorders (p= 0.012). Workers who have a history or are still smoking have a 1.9 times risk of experiencing mucociliary transport disorders.

Of the 331 workers with exposure for less than 10 years, the majority did not have mucociliary transport disorders, namely 282 workers (85.2%) and 49 workers (14.8%) had mucociliary transport disorders. Of the 269 workers with exposure for more than 10 years, the majority did not have mucociliary transport disorders, namely 218 workers (81%) and 51 workers (19%) had mucociliary transport disorders. The Chi Square test shows that there is no relationship between the length of exposure to mucociliary transport disorders (p= 0.212). Workers who are exposed for more

than 10 years have a 1.3 times risk of experiencing mucociliary transport disorders.

Of the 508 workers with a normal Body Mass Index, the majority did not have mucociliary transport disorders, namely 480 workers (94.5%) and 28 workers (5.5%) had mucociliary transport disorders. Of the 92 workers with an obesity Body Mass Index, the majority had mucociliary transport disorders, namely 72 workers (78.3%) and 20 workers (21.7%) did not experience mucociliary transport disorders. The Chi Square test shows that there is a relationship between the Body Mass Index and mucociliary transport disorders (p <0.001). Workers who have an obese Body Mass Index are 61 times more likely to experience mucociliary transport disorders.

Of the 543 workers who did not have diabetes mellitus (DM), the majority did not experience mucociliary transport disorders, namely 455 workers (83.8%) and 88 workers (16.2%) experienced mucociliary transport disorders. Of the 57 workers with diabetes mellitus (DM), the majority did not have mucociliary transport disorders, namely 45 workers (78.9%) and 12 workers (21.1%) did not experience mucociliary transport disorders. The Chi Square test shows that there is a relationship between diabetes mellitus and mucociliary transport disorders with p= 0.350. Workers who have diabetes mellitus have a 0.7 times risk of experiencing mucociliary transport disorders.

Of the 505 workers with good discipline in using PPE, the majority did not have mucociliary transport disorders, namely 487 workers (96.4%) and 18 workers (3.6%) experienced mucociliary transport. Of the 95 workers with poor discipline in using PPE, the majority had mucociliary transport disorders, namely 82 workers (86.3%) and 14 workers (15.4%) did not experience mucociliary transport disorders. The Chi Square test shows that there is a relationship between the discipline of using PPE and mucociliary transport disorders with p <0.001. Workers who are not disciplined in using PPE are at 292 times the risk of experiencing mucociliary transport disorders.

3. Multivariate analysis

The Table 6 shows 7 risk factors for nasal symptoms in workers, namely age, gender, smoking history, length of exposure, body mass index, diabetes mellitus and discipline in using PPE. Of the 7 risk factor variables for nasal symptoms, the most influential factor is discipline in using PPE with an OR of 88.15, meaning that workers who are not disciplined in using PPE while working are 88.1 times at risk of experiencing nasal symptoms. See Table 6 for influence of risk factors on symptoms of nasal disorders.

Table 6. Influence of risk factors on symptoms of nasal disorders

Variable	Adjust Odds Ratio	95% CI	
Age	1.70	0.65	4.48
Gender	0.57	0.18	1.76
Smoking history	1.27	0.44	3.70
Exposure time	2.17	0.84	5.56
BMI	11.37	4.08	31.68
DM	1.33	0.30	5.90
PPE	88.16	25.61	303.49

The Table 7 shows 7 risk factors for smell disorders in workers, namely age, gender, smoking history, length of exposure, body mass index, diabetes mellitus

and discipline in using PPE. Of the 7 risk factor variables for olfactory disorders, the most influential factor is discipline in using PPE with an OR of 14.90, meaning that workers who are not disciplined in using PPE while working are 14.9 times at risk of experiencing olfactory symptoms. See Table 7 for influence of risk factors on smell disorders.

Table 7. Influence of risk factors on smell disorders

Variable	Adjust Odds Ratio	95% CI	
Age	7.03	3.67	13.48
Gender	1.14	0.59	2.22
Smoking history	1.62	0.73	3.59
Exposure time	1.61	0.86	3.02
BMI	5.03	2.26	11.19
DM	0.36	0.14	0.96
PPE	14.91	6.50	34.19

The Table 8 shows 7 risk factors for smell disorders in workers, namely age, gender, smoking history, length of exposure, body mass index, diabetes mellitus and discipline in using PPE. Of the 7 risk factor variables for Mucociliary Transport, the most influential factor is discipline in using PPE with an OR of 75,283, meaning that workers who are not disciplined in using PPE while working are 14.9 times at risk of experiencing olfactory symptoms. See Table 8 for risk factors on mucociliary transport.

Table 8. Influence of risk factors on mucociliary transport

Variable	Adjust Odds Ratio	95% CI	
Age	6.26	2.59	15.13
Gender	1.76	0.72	4.31
Smoking history	0.41	0.13	1.28
Exposure time	0.75	0.32	1.74
BMI	10.51	3.98	27.73
DM	0.98	0.22	4.35
PPE	75.28	27.78	204.04

DISCUSSION

1. The Influence of Risk Factors on Symptoms of Nasal Disorders

The research results show that there are 7 risk factors for nasal symptoms in workers, namely age, gender, smoking history, length of exposure, body mass index, diabetes mellitus and discipline in using PPE. Of the 7 risk factor variables for nasal symptoms, the most influential factor is discipline in using PPE with an OR of 88.15, meaning that workers who are not disciplined in using PPE while working are 88.1 times at risk of experiencing nasal symptoms. Using PPE while working will minimize exposure to irritants that stimulate symptoms of nasal problems.

Symptoms of nasal problems can occur due to allergies to certain ingredients or fragrances and also non-allergic. Symptoms of nasal disorders are caused by changes in weather, drugs, hormones, dust, certain odors and food. In this case, 579 spice production workers were the group of workers most vulnerable to experiencing nasal symptoms. In producing spices, many

ingredients have various odors, besides exposure to dust when grinding raw materials to make spices increases the risk of workers experiencing nose problems. The most common symptoms experienced by workers are itching, sneezing and stuffy nose. The above characteristics are some of the characteristics of nasal disorders according to (Dobashi et al., 2020).

Symptoms of occupational rhinitis include nasal congestion, secretions, itching, sneezing, facial pressure, headaches, loss of sense of smell, formation of nasal crusts, dry nose, and nosebleeds caused by exposure to irritants in the workplace (Kotz et al., 2021b). This disease can be classified into allergic occupational rhinitis and non-allergic/irritant occupational rhinitis. Therefore, it is important to be disciplined in using Personal Protective Equipment or PPE for every job. The importance of use is proven by research results which state that workers who do not use PPE while working have 88.15 times the risk of experiencing nasal problems (Green et al., 2021).

2. The Influence of Risk Factors on Smell Disorders

Tobacco cigarettes contain a mixture of 5,000 chemicals including acrylic acid, acrolein, acetaldehyde, and chromium (VI) which have an effect on the olfactory epithelium (Mattos et al., 2018). Active components in tobacco cigarettes such as lipopolysaccharide add an important contribution to the damage to the olfactory epithelium. The neurotoxins contained in tobacco are known to cause impaired olfactory function. The impact of these substances can be felt indirectly due to cigarette consumption. In Brazil, it is estimated that 14.7% of the adult population smokes, and changes in olfactory function are common in this population (Etter et al., 2013). In another study, the prevalence of smell disorders was found to be 22.3%, where half of the sample were active smokers (47.4%). Smokers have a significantly increased risk of developing smell disorders compared to non-smokers (OR= 1.36, CI: 1.06–1.74) (Glennon et al., 2019).

According to Glennon et al., (2019), active components in tobacco cigarettes such as lipopolysaccharide add an important contribution to damage to the olfactory epithelium. Neurotoxins contained in tobacco are known to cause impaired olfactory function. In Brazil, it is estimated that 14.7% of the adult population smokes, and changes in olfactory function are common in this population (Etter et al., 2013). In another study, found a prevalence of smell disorders of 22.3% where half of the sample were active smokers (47.4%). Smokers have a significantly increased risk of developing smell disorders compared to non-smokers (OR= 1.36, CI: 1.06–1.74) (Glennon et al., 2019).

3. Influence of Risk Factors on Mucociliary Transport Disorders

Workers who are not disciplined in using PPE while working are 14.9 times at risk of experiencing olfactory symptoms. Personal protective equipment or PPE functions to protect oneself from the dangers of exposure to sharp objects, dangerous substances or air contamination in the surrounding environment (Werner & Nies, 2018). Discipline in using PPE minimizes mucociliary transport disorders. The use of PPE can prevent pathogenic particles from entering by inhalation. Pathogenic particles that enter the nose and are too late to eliminate them will cause a buildup of foreign objects, including dust from grinding raw materials for making spices, wood dust particles and the like (Hox et al., 2014). Cilia must always be covered by a layer of mucus to remain active. Dryness will quickly damage the cilia. The frequency of ciliary beats is also

influenced by dehydration, hypoxia, and hypercarbia. A lack of oxygen supply will slow down the movement of the cilia and a lot of oxygen will increase the frequency of ciliary beats by 30-50% (Hwang & Abdalkhani, 2003).

Even though the use of Personal Protective Equipment or PPE is able to minimize mucociliary transport disorders and is the strongest influencing factor, this does not mean ignoring other factors, such as temperature, humidity and environmental cleanliness (Irzal, 2016).

There is a significant association between occupational risk factors and nasal symptoms, olfactory disorders and mucociliary transport disorders. The most influential factor is discipline in using PPE to prevent nasal disorders, olfactory disorders and mucociliary transport disorders.

AUTHORS CONTRIBUTIONS

Conceptualization	AMKD, JW
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CONFLICT OF INTEREST

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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