Impaired Lung Function Due to Occupation by Exposure to Particulate Matter 2.5□m (PM2.5) in Fish Smokers

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Abstract

Backgrounds: As a coastal City, Ternate has smoked fish products that are traditionally managed by burning using firewood or coconut shells, resulting in air pollution pollutants, like fine particulate matter ($PM_{2.5}$), an air pollutants which are harmful to the health of fish smoking workers, such as pulmonary function impairment.

Purpose: This study aims to determine the effect of $PM_{2.5}$ exposure on lung function impairment of fish smoking workers in Ternate City.

Method: It was a cross-sectional study design, purposive sampling technique of 15 people from a total of 12 smoking houses.

Result: The median of $PM_{2.5}$ concentration in fish smoking houses was $440.15\mu g/m^3$ and about 86% of workers had been exposed to $PM_{2.5}$ exceeded the nationally required daily quality standard, 53.3% of respondents had lung function impairment based on FEV1/FVC lung capacity measurements, from the statistical analysis results obtained p = 1, meaning that there was no difference pulmonary function impairment in workers with $PM_{2.5}$ exposure that exceeds the quality standard and does not exceed the quality standard. OR 1.167 was obtained, meaning that workers exposed to $PM_{2.5}$ > quality standards have odds 1.167 times higher to have lung function impairment than workers exposed to $PM_{2.5} \leq$ quality standards.

Conclusion: Exposure to $PM_{2.5}$ that exceeds the quality standard will increase the risk of having lung function impairment in fish smoking workers in Ternate City.

Keywords: PM2.5, Lung Function Impairment, Smoked Fish, Workers, Air Pollution

Introduction

The global catch of marine fish in 2018 is estimated at 114.4 million tons. About 8% of global marine catches come from Indonesia (1). North Maluku is one of the marine fish producing provinces, it is estimated that around 288,187 tonnes of marine fish catch in 2019 (2). The majority of this abundant fish resource is intended for human consumption, but the storage capacity of fish is not long-lasting, which has led to the emergence of various alternative fish processing, one of which is smoked fish processing. Smoked fish is often found in coastal areas (3,4) and usually still in the form of a home industry and managed traditionally using coconut shell fuel or firewood which produces smoke containing anti-microbial compounds that inhibit the growth of putrefactive bacteria such as aldehydes, alcohols and ketones which also play a role in protein coagulation in fish so that the fish can survive from putrefactive bacteria (4).

The use of coconut shells and firewood can pose health risks, especially to fish smoking workers. Smoke from burning fossil fuels and burning biomass can produce pollutants consisting of particulate matter (PM2.5), CO_2, HC and NO_2 (4,5). Apart from transportation, biomass burning is the largest sector producing PM2.5, estimated at 22.58% (6). With its very small size, PM2.5 is able to penetrate further into the respiratory system (alveoli) and even transfer to organs outside the lungs, including the central nervous system, causing various health problems.

Research shows that those who use wood as the main fuel in cooking have significantly worse lung function than those who use charcoal. Wood smoke and poverty contribute to decreased lung function and the occurrence of COPD (7). Exposure to biomass smoke is one of the causes of health problems such as acute respiratory infections in children, chronic obstructive pulmonary disease, asthma and lung cancer(5). Based on national data, the prevalence of diseases related to air particulates, such as acute respiratory infections is 9.3%, Asthma is 2.4%, Pneumonia is 4.0%, while data for North Maluku Province, the prevalence of acute respiratory infections is 5.7%, Asthma is 1 .8%, and Pneumonia as much as 4.3% (8).

Ternate City is a coastal area that is rich in fish. Smoked fish is a popular product in Ternate City, but the smoking process is still carried out traditionally using burning firewood or coconut shells, thus producing pollutants, namely particulate matter (PM2.5). This pollutant is very dangerous for the health of fumigation workers as a group that is at risk of respiratory problems, one of which is impaired lung function. This research was conducted to determine the effect of PM2.5 exposure on lung function disorders in fish smoking workers in Ternate City.

Tools And Materials
The research design was a cross-sectional study to determine the effect of PM2.5 exposure on lung function disorders in fish smokers in Ternate City. This research has gone through an ethical review process from the Tanjungkarang Health Research Ethics Committee with ethical number No. 313/KEPK-TJK/XI/2020.

All fish smoking workers who work in 12 smoked fish production houses in Ternate City are the population of this study, the total population is 24 fish smoking workers. The samples were fish smoking workers determined by the inclusion criteria: had worked for at least 1 year as fish smoking workers, were healthy and willing to take part in all series of research, the sample was selected using purposive sampling technique, obtained were 15 fish smoking workers aged 16 - 67 years, who were has worked for more than 2 years as a fish smoking worker spread across 7 sub-districts in Ternate City. Data was collected in October - November 2020.

Measurement of lung function capacity was carried out using a DS-Pro Model SP10 digital spirometer, data were obtained on forced vital capacity (FVC), the first second of forced expiration (FEV1) and the comparison of FEV1 / FVC. PM2.5 data is measured using a particulate counter. Data on other demographic characteristics of respondents such as age, gender, history of chronic diseases, smoking habits and alcohol consumption, years of work, duration of work and home ventilation were also measured. Data was collected using a questionnaire that had been modified from standard questionnaires that had been used in previous similar studies. .

Measurements of environmental parameters, namely PM2.5, were carried out while fish smoking was in progress, measurements were carried out in the smoking room. The PM2.5 measurement results in real time are observed according to the numbers printed on the measurement tool. Environmental data is measured for 30 minutes and every minute the data is recorded and then averaged. Lung function data was collected by direct measurement of respondents, following spirometry examination procedures (9). Demographic characteristics were collected by direct interviews with currently employed workers.

The data that has been obtained is then analyzed using computer data analysis software, the data is analyzed univariately and bivariately. Analysis results are displayed with mean values, standard deviations, minimum and maximum values for numerical data and counts and proportions for categorical data. Bivariate analysis was carried out using the Chi Square test.

Results
The results of measuring PM2.5 exposure to fish smoking workers showed the lowest concentration was 31.15 µg/m³ and the highest was 6702.4 µg/m³ with an average value of 440.15 µg/m³. Indoor PM2.5 exposure has passed the quality standard (86.7%) based on the provisions of the Republic of Indonesia Minister of Health Regulation Number 1077/Menkes/PER/V/2011 concerning Guidelines for Healthy Air in

Home Spaces, namely (35 μg/m³). The results of univariate analysis of lung function disorders showed that 53.3% of fish smoking workers experienced lung function disorders.

The individual characteristics of fish smoking workers in Ternate City are predominantly female, have no history of chronic disease, and do not have the habit of smoking or consuming alcohol (Table 1). The average age of respondents is 43.67 years, has worked for 14 years, with a working duration of 8 hours per day (Table 2). Most respondents use firewood as fuel for smoking fish (80%) and live in houses with inadequate ventilation (80%), as many as 40% of respondents have a fish smoking room that is not separate from their home.

Table 1. Characteristics of respondents

Variable	n	%
Sex:		
Male	12	80
Female	3	20
History of chronic disease:		
Yes	3	20
No	12	80
Smoking habit:		
Smoke	3	20
Do not smoke	12	80
Habit of consuming alcohol:		
Consume	1	6,7
Do not consume	14	93,3

Table 2. Distribution of age, length of service and duration of work of respondents

Variable	Mean	SD	Range	95% CI
Age (Years)	43,67	13,3	16 – 67	36,30 – 51,03
Years of service (Years)	14,00	11,09	2 – 43	7,85 – 20,15
Working duration (hours)	8,00	2,51	2,5 – 14	6,60 – 9,39

Statistically, there is no significant relationship between PM2.5 concentrations and lung function disorders, however, an Odds ratio (OR) = 1.17 (0.06 – 22.94) is obtained, meaning that workers are exposed to PM2.5 that exceeds the quality standard. have 1.17 times higher odds of having impaired lung function compared to workers who are exposed to PM2.5 below or equal to the quality standard, and it is also known that there is no statistical relationship between gender ($p = 0.56$; OR = 2.8 (0.19 – 40.06)), length of work ($p = 1.00$; OR = 0.8 (0.10 – 6.34)), duration of work ($p = 0.31$; OR = 0.25 (0.03 – 2.24)) and home ventilation ($p = 0.56$; OR = 0.35 (0.03 – 5.11)) with impaired lung function (Table 3).

Table 3. Relationship between lung function disorders and PM2.5 concentration, gender, work period, work duration and home ventilation.

Variable	Lung function disorders (n=15)				OR (95% CI)	p
	Yes		No			
	n	%	n	%		
PM concentration $_{2,5}$ (µg/m³):						
> Quality standards	7	53,8	6	46,2	1,17	1,00
≤ Quality standards	1	50,0	1	50,0	(0,06 – 22,94)	
Sex:						
Female	7	58,3	5	41,7	2,8	0,56
Male	1	33,3	2	66,7	(0,19 – 40,06)	
Years of service:						
≥ 25	3	50	3	50	0,8	1,00
< 25	5	55,6	4	44,4	(0,10 – 6,35)	
Duration of work:						
> 8	2	33,3	4	66,7	0,25	0,31
≤ 8	6	66,7	3	33,3	(0,03 – 2,24)	
Air ventilation:						
Adequate	1	33,3	2	66,7	0,35	0,56
Inadequate	7	58,3	5	41,7	(0,03 – 5,11)	

Discussion

PM2.5 concentration with impaired lung function

The average concentration of PM2.5 in fish smoking houses is 12 times higher than the threshold value required by the government (9). This high concentration of PM2.5 is possible due to the use of firewood as fuel or a mixture with coconut shells in the fish smoking process. This will of course affect the health of workers who are constantly exposed to PM2.5. The same research also showed that the PM2.5 concentration at a fish smoking location had exceeded environmental quality standards (4) In line with Pramitha's research, the average indoor PM2.5 exposure in Jakarta is 308 µg/m³ (10). WHO states that PM sources mostly come from human activities, are usually concentrated in certain areas such as industrial areas and have a greater impact on health (11).

The percentage of respondents who have lung function disorders is greater than respondents who do not have lung function disorders. In line with previous research, the majority of respondents who work in fish smoking have abnormal lung function capacity (12), Apart from that, it has been reported that burning biomass in the fish smoking industry will reduce lung capacity and increase respiratory problems (3).

This research shows that there is no statistically significant relationship between PM2.5 concentrations and lung function disorders, this could be influenced by the limited number of samples in this study. This is in line with research conducted by Aulia, 60% of workers have abnormal lung function even though PM2.5 levels are far below the quality standard (0,481 µg/m³) (13). Although the relationship analysis shows that there is no significant relationship between PM2.5 and lung function, the OR value shows that workers who are exposed to PM2.5 exceeding the safe limit have higher odds of having lung function disorders compared to workers who are exposed to PM2.5 below the safe limit. limits. This is possible because workers who are exposed to dust particles that exceed the limit value will have a greater risk of dust particles entering the alveoli through various mechanisms, causing pulmonary fibrosis, then the lungs will become stiff and cause lung expansion disorders, namely restrictive functional disorders. (14).

PM2.5 is a particulate that has aromatic hydrocarbon and heavy metal components (15) which can act as an initiator in generating reactive oxygen species (ROS), which is the cause of oxidative stress and inflammatory responses (16) furthermore, it plays a role in the occurrence of diseases such as cancer, asthma and other respiratory diseases when oxidant defenses are inadequate.

Gender with impaired lung function
The results of the analysis showed that there was no significant relationship between gender and lung function disorders in fish smoking workers. This could be because the majority of workers in the fish smoking industry are women. Although there is no statistically significant relationship between gender and lung function disorders, the results show that the majority of female workers have lung function disorders compared to men. Apart from the fact that more of the respondents in this study were women, this could also be influenced by the fact that women have a longer duration of exposure to PM2.5 than men, such as PM2.5 which comes from burning biomass in their daily activities such as cooking. increases the risk of experiencing impaired lung function. In line with previous research, it shows that the prevalence of chronic bronchitis symptoms occurs more in women who work in the fish smoking industry than in women who do not work in the fish smoking industry (17).

The same results were also shown in Rahmanian's research that women had a significantly lower FEV1/FVC ratio than men (18) This can be influenced because women have smaller lung anatomy than men. Lung volume, lung elasticity, lung strength and respiratory muscle coordination will influence the peak expiratory flow (peak expiratory flow) therefore women can have lower peak expiratory flow values than men (10)

Working period, duration of work with impaired lung function
The length of time working as a fish smoker is used to determine the length of exposure to PM2.5 pollutants at the work site which of course will affect the health status of workers. Statistically, there is no significant relationship between length of service and apru function disorders in this study, this could be influenced by the small number of samples, however, the results obtained are that fish smoking workers who have worked ≥25 years have odds 0.8 times higher to have impaired lung function compared to workers with <25 years of service. This is in line with Mengkidi's research stating that there is a significant relationship between working years and lung function disorders (19). This is also in line with previous research that 66.7% of workers with a working period of >5 years had abnormal lung function (13)

Work duration is the length of time fish smoking workers are exposed to PM2.5 pollutants every day. A good work duration for workers is around 6-10 hours per day, work duration of more than 8 hours a day will put a worker at greater risk of exposure to pollutants arising from the work environment. The results of the analysis of the relationship between work duration and lung function disorders showed that there was no statistically significant relationship, but the OR value showed that workers with work duration >8 hours had 0.25 times higher odds of having lung function disorders than workers with work duration ≤8 O'clock. This is possible because continuous and long-term exposure to PM2.5 will further increase the risk of health problems.

In line with previous research, fish processing workers who work ≥8 hours a day are at risk of experiencing respiratory complaints and long working hours are factors that cause decreased lung function (4) and the majority of workers who work >8 hours experience impaired lung function (19).

Ventilation and lung function disorders
This research shows that there is no relationship between ventilation and lung function events, the majority of respondents have adequate ventilation in the form of windows and doors. The results of this study are inversely proportional to previous research, which stated that there was a relationship between home ventilation and lung function disorders in adults in Jakarta (10). Research in Nigeria shows that ventilation in the kitchen will reduce pollution resulting from cooking and other biomass burning activities such as PM2.5 (17). Biomass burning is the largest sector producing PM2.5 after transportation (6). With its very

small size, PM2.5 is able to penetrate further into the respiratory system (alveoli) and even transfer to organs outside the lungs, including the central nervous system, causing various health problems.

There are shortcomings in this research, such as the sampling technique which is not random sampling, the number of research subjects is small, this is because the average number of workers in the fish smoking house industry only consists of one or two workers, in addition to the ability of respondents who are not used to it. in taking spirometry measurements, it is possible to produce results that are not optimal, making it possible to obtain results that are not statistically related to the variables studied. In addition, this study did not compare exposed and unexposed groups.

Conclusions

The average PM2.5 concentration in fish smoking houses is 12 times higher than the threshold value required by the government. As much as 86.7% of workers' exposure to PM2.5 has exceeded quality standards. The prevalence of fish smoking workers who experience lung function disorders is 53.3%. Statistically, there was no significant relationship between PM2.5 concentrations and lung function disorders, but the OR value = 1.167 was obtained, meaning that workers exposed to PM2.5 >safe limit had 1.167 times higher odds of having lung function disorders compared to workers exposed to PM2. .5 ≤ safe limit. There needs to be efforts to control indoor air pollution in fish smoking houses so that the health risks to fish smoking workers can be minimized

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