Medica Hospitalia
Journal of Clinical Medicine
Med Hosp 2024; vol 11 (2) : 160–166

OPEN ACCESS

Original Article

Comparing the Pulmonary-Spirometry in Laboratory Workers Who Wear Acchadana® and KN95® Masks

Fathur Nur Kholis[1], Resti Ariani[2], Awal Prasetyo[3], Rina Puspita[2], Udadi Sadhana[4], Ika Pawitra M[4], Hermawan Istiadi[4]

[1]Pulmonology Division Department of Internal Medicine, Faculty of Medicine, Diponegoro University / Kariadi Hospital, Semarang, Indonesia
[2]Blood Bank Technology, Bina Trada Polytechnic, Semarang, Indonesia
[3]Department of Biomedical Science, Faculty of Medicine, Diponegoro University, Semarang, Indonesia
[4]Department of Anatomic Pathology, Faculty of Medicine, Diponegoro University/Kariadi Hospital, Semarang, Indonesia

p-ISSN: 2301-4369 e-ISSN: 2685-7898
https://doi.org/10.36408/mhjcm.v11i2.1076

Accepted: February 15th, 2024
Approved: June 05th, 2024

Author Affiliation:
Pulmonology Division,
Department of Internal Medicine,
Faculty of Medicine, Diponegoro University / Kariadi Hospital, Semarang, Indonesia

Author Correspondence:
Fathur Nur Kholis
Dr. Sutomo Street No. 16, Semarang,
Central Java 50244, Indonesia

E-mail:
drfnkholis@gmail.com

Abstract

Background : The upper respiratory tract is susceptible to inflammation caused by exposure to airborne contaminants, particularly chemical irritants. Inhaled irritant gases can lead to various symptoms and adverse reactions in the respiratory tract. Laboratory workers are at a high risk of respiratory tract inflammation due to exposure to volatile chemicals. The use of personal protective equipment (PPE), such as masks, is essential to prevent inflammation and protect the respiratory tract. Lung function tests using spirometry, including Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second ($FEV_{1.0}$), and Peak Expiratory Flow (PEF), can help identify abnormalities in lung function. The primary objective of this investigation is to juxtapose the pulmonary conditions of laboratory workers before and after the utilization of KN95® masks and Acchadana® masks.
Methods : The study design was a Randomized Control Trial, and the subjects were divided into two groups: the control group wearing KN95 masks and the treatment group wearing Acchadana® herbal masks. Spirometry measurements were taken before and after using the masks, and statistical analysis was conducted to compare the results.
Results : The results showed that both mask groups experienced improvements in lung function parameters after using the masks. However, the KN95 mask group showed better lung conditions compared to the Acchadana® mask group.
Conclusion : Spirometry tests conducted on lab workers revealed improved lung function metrics (including FVC, $FEV_{1.0}$, and PEF) following the usage of KN95 masks and Acchadana® herbal masks. The KN95 mask users exhibited superior respiratory health compared to the other group in this investigation.

Keywords : Personal Protective Equipment, KN95 mask, Acchadana, Spirometry, Lung function

INTRODUCTION

The upper respiratory tract is the first line of direct exposure to various airborne contaminants and susceptible to sustain inflammation.[1] Pollutants in the form of chemical irritants that evaporate in gas form are the most likely triggers to inflammation and other adverse reactions in the upper and lower respiratory tract. The number of inhaled irritants will give different symptoms and body responses such as excess mucus production, breathing discomfort, impaired lung function, and other severe symptoms.[2,3]

The lungs are the organs most vulnerable to chemical irritant substances. The effects caused by inhaling irritant gases are highly dependent on the level of concentration and duration of exposure. Dissolved irritant gas causes a burning sensation and other manifestations such as eye, nose and bronchial irritation.[4] Inhalation of irritant gases such as chlorine, ammonia, sulfur dioxide and hydrogen chloride causes irritation of the mucous membranes in the upper respiratory tract.[4] These conditions synergistically trigger hypersecretion.[1,5] Common responses to inhalation of various irritant gases include inflammation, edema and sloughing of the epithelium which, if left untreated, can lead to scar formation and remodeling of the lung and airways.[6]

Laboratory workers are the group that uses the most volatile chemicals, the risk of experiencing inflammation of the upper and lower respiratory tract is higher than workers in other sections.[1,3] The easiest way to prevent inflammation of the respiratory tract and lungs is by using personal protective equipment (PPE) in the form of a mask.[1,3] The use of PPE in environments with exposure to chemicals allows for upper respiratory tract protection, so that gases or chemical vapors in the air are not easily inhaled. Continuous inhalation of reactive chemicals can result in decreased lung function.[1,3]

At a certain period of time, it is important for laboratory workers to carry out examinations to find out whether lung spirometry is normal or not.[7] Abnormalities in lung function can be identified by carrying out lung function tests using spirometry, one of which is forced vital capacity (FVC), forced expiratory volume at 1 second ($FEV_{1.0}$) and peak expiratory flow (PEF).[8] However, the interpretation of pulmonary function examination results is influenced by several factors, namely gender, age, height, ethnicity, body surface mass of an individual.[9,10]

The efficacy of personal protective equipment (PPE) in the form of masks necessitates a consideration of their quality and protective capabilities. The safeguarding of the respiratory tract against exposure to airborne pollutants, encompassing both particulate matter and gases, is suboptimal when employing conventional cloth masks alone. Empirical evidence establishes that KN95® masks and herbal Acchadana® masks exhibit comparable efficacy in protecting the respiratory tract. Notably, a comparative analysis revealed that, over a span of two months, the utilization of herbal masks resulted in a statistically significant increase in mean FVC, $FEV_{1.0}$, PEF when contrasted with ordinary cloth masks.[11] Consequently, it was deduced that herbal masks exhibit superior efficacy in enhancing lung function. The primary objective of this investigation is to juxtapose the pulmonary conditions of laboratory workers before and after the utilization of KN95® masks and Acchadana® masks.

METHODS

Study Design

This research was a Randomized Control Trial, with a purposive sampling technique. The subjects were 50 laboratory workers from different laboratories (blood service, blood component, serology-hematology and infection). Each laboratory was taken half randomly and divided into two groups. The control group wore KN95® masks (n=25) and the treatment group wore Acchadana® herbal masks (n=25, 1 drop out). Each subject received a mask according to the group, which was given periodically every two weeks.

The inclusion criteria involved subjects who were in good health condition based on the results of a doctor's examination, and who were willing to participate in research by signing informed consent. Exclusion criteria included subjects who were pregnant, heavy smokers, had consumed alcohol and had a history of respiratory problems, allergic rhinitis and asthma. Masks produced by CV. Beauty Kasatama Surabaya. The research subjects wore masks for 60 days (maximum of 8 hours/day), then were examined for spirometry.

Spirometry measurement

Pulmonary function parameters measured in this study were Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second ($FEV_{1.0}$), and Peak Expiratory Flow (PEF). Measurement of pulmonary function parameters was done using Medical International Research Spirolab III portable spirometer before and after using mask. This research has received approval from the Ethics Commission of the Faculty of Medicine UNDIP with number 152/EC/KEPK/FK-UNDIP/VI/2022.

Acchadana® Herbal Mask and KN95® Mask

Herbal mask extract Acchadana® *Nephrolepis exaltata* – *Hibiscus rosa sinensis* was made at the Diponegoro University Applied Sciences Laboratory. Acchadana® masks have received brand patents with No. IDM000921225 and KN95® Masks with coded GB2626-2006.

Statistical analysis

Data normality test from each group was analyzed using the Shapiro-Wilk test. The mean differences between FVC, $FEV_{1.0}$, and PEF values before and after treatment in both groups were analyzed using paired-t Test since all data showed normal distribution. Data that were not normally distributed were analyzed by the Mann-Whitney Test, a significant difference test if p <0.05.

RESULTS

Subjects participating in this study consisted of 79.6% male and 20.4% female. The research subjects were divided into 2 groups of masks, namely KN95 masks which consisted of 80% men and 20% women. In the Acchadana® herbal mask group, 79.2% were men and 20.8% were women. In the KN95® mask group there were 8% of subjects with a history of smoking, while in the Acchadana® herbal mask group there were 16.7% of subjects. There were only 2 (8%) subjects with respiratory problems in the KN95® mask group. In the Acchadana® herbal mask group, all subjects had no history of respiratory problems (Table 1).

The paired difference test of the FVC pre-test and FVC post-test in Table 2 showed that the KN95 mask group increased significantly with a *p-value* = <0.001 (p <0.05), while the Acchadana® mask group experienced an increase but not significantly statistics with a *p-value* = 0.051. The results of the unpaired different test on FVC pretest group between KN95 and Acchadana® showed no significant difference. There is a significant difference in FVC between KN95® and Acchadana® *p-value* = 0.042 (p<0.05). The difference in FVC values between the KN95® and Acchadana® mask groups was presented in the box plot diagram in Figure 1.

The results of the paired difference test $FEV_{1.0}$ pre-test and $FEV_{1.0}$ post-test increased significantly in both mask groups (p<0.05), KN95 masks *p-value* = <0.001, and Acchadana® masks *p-value* = 0.045. Unpaired different test on $FEV_{1.0}$ pre-test between KN95® and Acchadana® masks there was no significant difference. However, the difference in $FEV_{1.0}$ between the KN95® and

TABLE 1
Demographics and research subject data based on mask groups

Characteristics		Mask					
		KN95®			Acchadana®		
		n	%	Mean ± SD (min–max)	n	%	Mean ± SD (min–max)
Age				33.36 ± 8.93			33.96 ± 9.47
Gender	Man	20	80.0		19	79.2	
	Woman	5	20.0		5	20.8	
Blood pressure	Systolic			130.20 ± 24.45			122.38 ± 21.76
	Diastolic			82.88 ± 10.35			79.33 ± 12.87
Smoking history	Yes	2	8.0		4	6	
	No	23	90.0		20	5	
Respiratory disorders	Yes	2	8.0		0		
	No	23	92.0		24	100	

TABLE 2
Statistical analysis of FVC

Mask	FVC		*p*	Delta
	Pre	Post		
KN95®	71.75 ± 14.72	89.19 ± 22.23	<0.001¶*	17.44 ± 16.45
Acchadana®	75.99 ± 11.14	83.99 ± 19.51	0.051¶	7.32 ± 17.42
p	0.256¥	0.459§		0.459§

Note: *Significant (p < 0.05); ¥ Independent t; § One Way Anova (Welch); ¶ Paired t

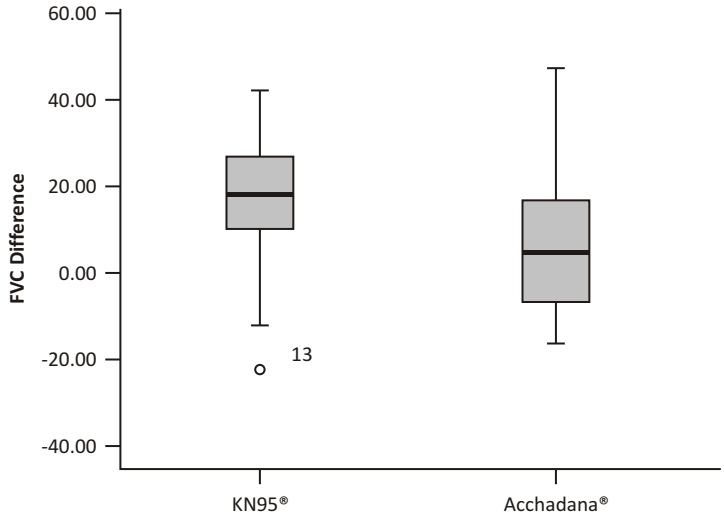

Figure 1. Difference in FVC between groups of KN95® masks and Acchadana® masks

TABLE 3
Statistical analysis of $FEV_{1.0}$

Mask	FEV1		*p*	Delta
	Pre	Post		
KN95®	81.94 ± 16.84	101.14 ± 23.67	<0.001¶*	19.20 ± 18.08
Acchadana®	88.09 ± 13.10	97.30 ± 21.89	0.045¶*	8.39 ± 19.43
p	0.156¥	0.475§		0.049¥*

Note: * Significance ($p < 0.05$); ¥ Independent t; § One Way Anova (Welch); ¶ Paired t

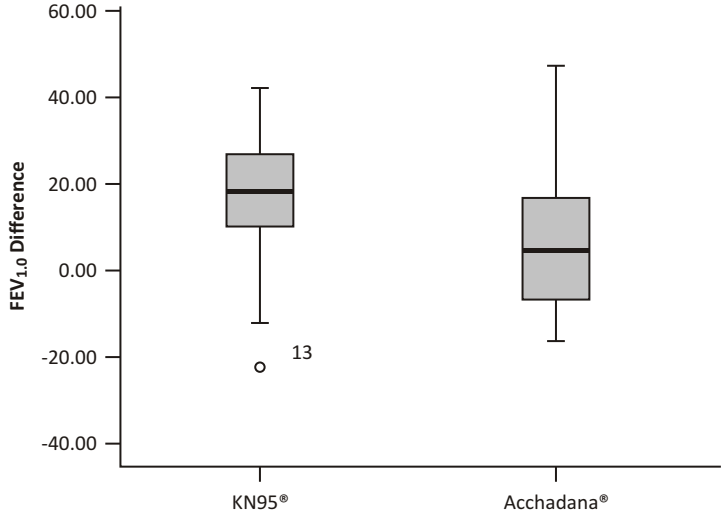

Figure 2. Difference in $FEV_{1.0}$ between groups of KN95® mask and Acchadana® mask

Acchadana® masks was significantly different with a *p-value* = 0.049 ($p < 0.05$) (Table 3). The difference in $FEV_{1.0}$ values between the KN95® mask group and the Acchadana® mask was presented in the box plot diagram in Figure 2.

The results of the paired difference test PEF pre-test and PEF post-test also increased significantly in the two mask groups. KN95® mask and Acchadana® mask have *p-value* = <0.001 and *p-value* = 0.044 ($p<0.05$). There was no significant difference in the results of the unpaired

TABLE 4
Statistical analysis of PEF

Mask	PEF		*p*	Delta
	Pre	Post		
KN95®	89.61 ± 17.86	117.16 ± 36.87	<0.001¶*	27.55 ± 28.36
Acchadana®	97.24 ± 28.25	111.54 ± 26.77	0.044¶*	13.80 ± 31.66
p	0.259¥	0.729§		0.187†*

Note: * Significance (p < 0.05); ¥ Independent t; § One Way Anova (Welch); ¶ Paired t; † Mann Whitney

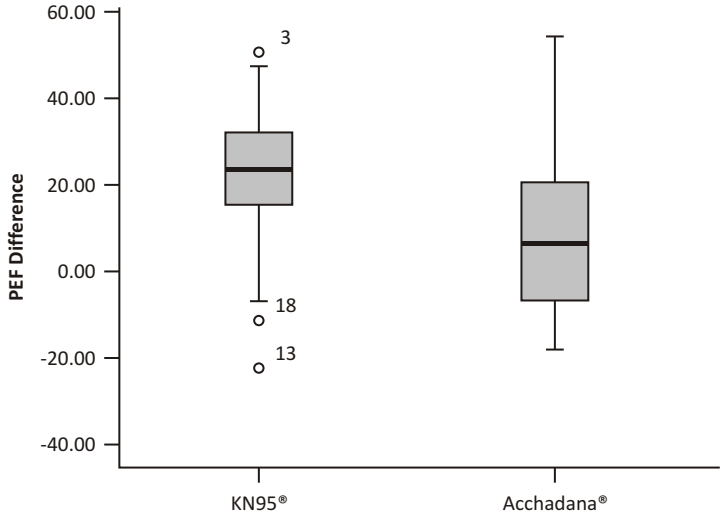

Figure 3. Difference in PEF between groups of KN95® mask and Acchadana® mask

difference test on the PEF pre-test, post-test and delta between KN95® and Acchadana®. The PEF pre-test has a *p-value* = 0.259. Meanwhile, the PEF post-test *p-value* = 0.729, and the PEF delta *p-value* = 0.187 (Table 4).

The difference in PEF values between the KN95® and Acchadana® mask groups was presented in the box plot diagram in Figure 3.

DISCUSSION

This study involved subjects of laboratory workers who were vulnerable to exposure to volatile chemical irritants in the work environment. Twenty-five subjects used KN95® mask and Acchadana® herbal mask while working. Acchadana® herbal mask contains *Nephrolepis exaltata* and *Hibiscus rosasinensis*. Both of these masks have equal protection in protecting the respiratory tract. The use of masks correctly and continuously during the study showed that the condition of the respiratory tract remains good even when working with chemicals. However, unfortunately the chemicals are easily vaporized and are at risk of inhalation. The general cascade of responses to inhaled irritant gases usually begins with inflammation of the respiratory tract epithelium.[12] Apart from causing respiratory allergies such as bronchial asthma and hypersensitivity pneumonitis, exposure to chemicals is reported to cause a series of diseases that interfere with lung function.[2] Exposure to chemicals for a long time and continuously can trigger edema and increase mucus secretion in the respiratory tract. On the other hand, inflammation occurs in the respiratory tract and lung parenchyma resulting in decreased lung function.[11]

Inhalation of pollutants in the air and gases chronically impairs lung function and can cause lung disorders.[13] The parameters tested in the study were the assessment of FVC, $FEV_{1.0}$, PEF. FVC examination is performed to analyze the maximum amount of air that can be exhaled after taking the deepest possible breath. Previous studies reported that patients with airway obstruction and increased expiratory airflow resistance needed 25–30 seconds to expel their entire vital capacity, whereas normal subjects only needed 3 seconds.[14]

In theory, forced vital capacity decreases with age.[15] In this study, FVC in the KN95® and Acchadana® groups both increased after using masks for eight weeks. Apart from the well-protected workers' respiratory tract,

these results are also likely to be influenced by the subject's age, which is around 30 years old on average. In younger individuals, lung function typically peaks, characterized by optimal respiratory capacity and efficiency. However, the interpretation of pulmonary function examination results is also influenced by several other factors, namely gender, height, and ethnicity.[9,10]

It is important to evaluate the volume of air in the first second of expiration. A value of $FEV_{1.0}$ that is reduced by more than FVC is a marker for an obstructive disorder. Measurement of the volume of gas expelled during a 1 second time interval in both mask groups showed a significant increase in the $FEV_{1.0}$ score compared to before using the mask. The percentage of severity of airflow obstruction on the $FEV_{1.0}$ examination in this study was included in the mild category with a value of >80%. Severity is included in the moderate category if the subject's $FEV_{1.0}$ value is at a score of 50–79%, and the severe category if it drops to 30–49%.[7]

Maximum flow rate (PEF) during expiration can also be read on spirometry. Exhaled air in a spirometer is recorded as a spirogram, which is calibrated against volume changes.[14] A decreased PEF value indicates obstruction to airflow in the airways, an indication of asthma with early airway obstruction, and often occurs in restrictive lung disease due to reduced volume.[16,17] The PEF scores of the KN95® mask and Acchadana® mask groups increased significantly after wearing the mask for four weeks. These results indicate no increased airway resistance.

The superior lung function observed in the KN95 mask group compared to the Acchadana® herbal mask group could be attributed to several factors. Firstly, KN95 masks are designed to provide a high level of filtration efficiency, effectively blocking a greater proportion of airborne particles and irritants from entering the respiratory system. This enhanced filtration capability may lead to reduced exposure to irritants, thereby resulting in less inflammation and better lung function over time.

Additionally, KN95 masks are manufactured according to standardized guidelines, ensuring consistent quality and fit, which is crucial for optimal respiratory protection. On the other hand, while Acchadana® herbal masks may offer certain herbal benefits, their filtration efficiency and consistency in protecting against airborne contaminants may not match that of KN95 masks.

This study still had limitations, including monitoring the use of masks and the compliance of each subject during the research. Even though each group of subjects had been given an understanding of adherence to wearing masks during the study period, this was still difficult to control. Measurement of vital capacity when exhaling air must be ensured that the subject really has maximized the impact when exhaling post-inspired air. More investigation is necessary to explore the efficacy of herbal masks in comparison to conventional PPE protocols.

CONCLUSION

Spirometry examination of laboratory workers showed that all lung function parameters (FVC, $FEV_{1.0}$, and PEF) experienced an increase in scores after using KN95 masks and Acchadana® herbal masks. In this study, the KN95 mask group showed better lung conditions.

Acknowledgement
This article is part of a research program supported from research grant of Faculty of Medicine, Diponegoro University (no: 4511/UN7.5.4.2.1/PP/2020). The authors acknowledge Jessica Novia and Kevin Gracia Pratama, who provided support in editing, formatting, and translating the manuscript.

REFERENCES

1. Shusterman D. The effects of air pollutants and irritants on the upper airway. Proc Am Thorac Soc. 2011 Mar;8(1):101–5.
2. Morimoto Y, Nishida C, Tomonaga T, Izumi H, Yatera K, Sakurai K, *et al*. Lung disorders induced by respirable organic chemicals. J Occup Health. 2021;63(1):e12240.
3. Pemberton MA, Kimber I. Classification of chemicals as respiratory allergens based on human data: Requirements and practical considerations. Regul Toxicol Pharmacol RTP. 2021 Jul;123:104925.
4. Jones SW, Williams FN, Cairns BA, Cartotto R. Inhalation Injury: Pathophysiology, Diagnosis, and Treatment. Clin Plast Surg. 2017 Jul;44(3):505–11.
5. Jiang XQ, Mei XD, Feng D. Air pollution and chronic airway diseases: what should people know and do? J Thorac Dis. 2016 Jan;8(1):E31–40.
6. Ojanguren I, Moullec G, Hobeika J, Miravitlles M, Lemiere C. Clinical and inflammatory characteristics of Asthma-COPD overlap in workers with occupational asthma. Plos One. 2018 Mar 2;13(3):e0193144.
7. Knox-Brown B, Mulhern O, Feary J, Amaral AFS. Spirometry parameters used to define small airways obstruction in population-based studies: systematic review. Respir Res. 2022 Mar 21;23(1):67.
8. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, *et al*. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. Am J Respir Crit Care Med. 2019 Oct 15;200(8):e70–88.
9. Moore VC. Spirometry: step by step. Breathe. 2012 Mar 1;8(3):232–40.
10. Haynes JM. Basic spirometry testing and interpretation for the primary care provider. Can J Respir Ther CJRT Rev Can Thérapie Respir RCTR [Internet]. 2018 Winter [cited 2023 Nov 27];54(4). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6516140/
11. Prasetyo A, Adi Rahardja A, Tsuroya Azzahro D, Pawitra Miranti I, Saraswati I, Nur Kholis F. Nephrolepis exaltata Herbal Mask Increases Nasal IgA Levels and Pulmonary Function in Textile Factory Workers. Adv Prev Med. 2019;2019:5687135.

12. Pauluhn J, Whalan JE. Human risk assessment of inhaled irritants: Role of sensory stimulations from spatially separated nociceptors. Toxicology. 2021 Oct;462:152929.
13. Aleemuddin M, Goothy SSK, Rao DS, Firdous J, Mayasandra ML. A study of dynamic pulmonary function tests in street cleaners. Asian J Med Sci. 2022 Oct 1;13(10):237–42.
14. Bakhtiar A, Tantri RIE. Faal Paru Dinamis: [Dynamic Lung Function]. J Respirasi. 2017 Sep 30;3(3):89–96.
15. Sharma C, Badyal A. Pulmonary function tests: a study among healthy individuals of different age groups in Akhnoor Tehsil. Int J Clin Trials. 2021 Apr 22;8(2):134–7.
16. Ali MNA, Jasim AH, Nassr AN, Kaddish MA. Forced vital capacity (FVC), peaked expiratory flow rate (PEFR), are additional parameters in the assessment of the reversibility test. J Fac Med Baghdad. 2018 Apr 1;60(1):24–7.
17. Wanger J, Clausen JL, Coates A, Pedersen OF, Brusasco V, Burgos F, *et al*. Standardisation of the measurement of lung volumes. Eur Respir J. 2005 Sep 1;26(3):511–22.