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IMPACT OF ULTRAVIOLET RADIATION ON BACTERIAL GROWTH OF KN95 MASK

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ABSTRAK

Abstract:
Pandemic SARS CoV-2 is currently spreading around the world. Preventive measures to be implemented include using Personal Protective Equipment (PPE) especially mask which lead to a lack of mask supply. Strategy is proposed by decontaminating it so that it can be used repeatedly. This research was conducted to compare the effectiveness of UV radiation disinfection in different duration on the KN95 mask. This research was conducted by decontaminating of KN95 mask using UV radiation with radiation time of 15, 30, and 45 minutes. The mask was swab before and after the radiation. Examination for the growth of pathogen bacterial colonies and total plate count method was done to determine the effectivity. It was found the number of germs before and after has decreased significantly radiation at 30 (P = 0.036) and 45 minutes (P = 0.037). It also can be effective in decontaminating pathogen bacterial as the number colony of *Staphylococcus aureus* has decreased significantly in 30 minutes (P=0.034) and 45 minutes exposure (P= 0.037). The results of this study indicate that UV radiation for 30 and 45 minutes can be effective in decontaminating pathogen bacterial.

Abstrak:
Pandemi SARS CoV-2 saat ini sedang menyebardi seluruh dunia. Upaya preventif yang dilakukan dengan penggunaan Alat Pelindung Diri (APD) khususnya masker. Hal ini mengakibatkan berkurangnya pasokan masker. Salah satu alternatif dari masalah ini adalah dengan melakukan dekontaminasi sehingga masker dapat digunakan berulang kali. Penelitian ini dilakukan untuk membandingkan efektivitas disinfeksi radiasi UV dengan durasi yang berbeda pada masker KN95. Penelitian ini dilakukan dengan dekontaminasi masker KN95 menggunakan radiasi UV dengan waktu penyinaran 15, 30, dan 45 menit. Masker dilakukan swab sebelum dan sesudah radiasi. Pemeriksaan pertumbuhan koloni bakteri patogen dan metode angka lempeng total dilakukan untuk mengetahui efektivitas. Ditemukan jumlah kuman sebelum dan sesudah penyinaran menurun secara signifikan pada 30 (P = 0,036) dan 45 menit (P = 0,037). Koloni bakteri pathogen Staphylococcus aureus juga mengalami penurunan signifikan pada paparan 30 menit (P=0,034) dan 45 menit (P=0,037). Hasil penelitian ini menunjukkan bahwa penyinaran UV selama 30 dan 45 menit dapat efektif dalam dekontaminasi bakteri patogen.

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INTRODUCTION

Acute respiratory infections due to SARS CoV-2 are currently spreading rapidly around the world and have become a public health problem. This infection is called the novel coronavirus disease (COVID-19) [1]. COVID 19 is mostly spread via droplets and then through contaminated surfaces. Recent studies have shown that COVID 19 can persist on surfaces within hours or days [2]. Preventive measures to prevent the spread of this disease are washing hands, using masks, regularly disinfecting surfaces; avoiding touching the eyes, nose, and, mouth; and doing physical distancing [3]. Additional precautions are needed by health workers to protect themselves and prevent transmission [4]. Preventive measures to be implemented by health workers treating patients with COVID-19 include using Personal Protective Equipment (PPE) [3]. The use of PPE, including gloves, gowns, procedure masks, respirators, and eye protection (face shield or goggles), is recommended for single use. However, during a pandemic, an increase in the demand for PPE can lead to a lack of PPE supply, so a strategy is proposed to save PPE use by decontaminating it so that it can be used repeatedly[3].

Decontamination is a combination of processes including cleaning, disinfection, and/or sterilization of reusable materials that have been used for reuse [5]. The process of disinfection and sterilization of materials can be carried out in various ways. Viscussi, et al. In 2019 conducted sterilization using the hydrogen peroxide liquid-vapor method, finding that this method had no significant effect on aerosol penetration or filter airflow resistance on masks [6]. Another method used is to use ultraviolet radiation this method could reducing the level of viral RNA that could be detected on rT PCR [7]. However, only several researchs mention about the duration of radiation. This research was conducted to compare the effectiveness of the UV radiation disinfection in different duration on the KN95 mask so that it can be used repeatedly.

RESEARCH METHOD

This study used a quasy experimental method. In this study, sterilization was carried out on the 3M brand KN95 mask using the UV sterilization method. The UV lamp used is Evaco brand UV lamp with a power of 20 watts and 254 nm wavelenghts. The differences in treatment were given in the duration of irradiation, which are 15, 30, and 45 minutes, respectively. The gap between of each mask to the lamp approximately 30 cm. Before UV irradiation was done, we did Swab in the inside of 3 KN95 masks that had been used by health workers for about 6 hours. After sterilization using UV, the swab is done again on the inside of the mask. The media were transported to The Laboratory of Health and Calibration West Nusa Tenggara Province to be examined. We examined the total plate count number of bacteria also colonies of pathogenic bacteria, which are *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* which is planted on Blood Agar, Mc Konkey and Nutrient Agar media. Other bacteria than the three bacteria mentioned above also were identified. The total plate count results from the three methods from each test were compared using the paired t-test method using IBM SPSS statistics.

RESULTS AND ANALYSIS

On the examination of the total plate numbers, the results are as shown in table 1. In table 1, it can be seen that the total plate number decreased after radiation with UV light. The longer duration of exposure, shows lower the total plate count value, which is a sign that the sterilization has been successful. The total plate number compared for any difference using the paired t test. Before the paired t test was

done, the normality test was carried out using the Sapphiro Willik test and obtained data with a normal distribution. Then the paired t test was performed by comparing the total plate numbers that had been swab before and after UV exposure with 15, 30, 45 minutes. At the time of exposure to 15 minutes, there was no significant difference between of total plate count (P = 0.071). However, there was a significant difference of total plate counts of bacterial before and after radiation at 30 (P = 0.036) and 45 minutes (P = 0.037).

Table 1.
Total Plate Count of Bacterial

Total Plate Count of Bacterial					
Pre 15 Minutes UV	**Post 15 Minutes UV**	**Pre 30 Minutes UV**	**Post 30 Minutes UV**	**Pre 45 Minutes UV**	**Post 45 Minutes UV**
17	11	7	0	55	3
15	0	14	0	125	30
20	12	10	0	121	14
P=0.071		**P=0.036**		**P= 0.037**	

On Pathogenic bacterial examination, it was found that there was a decrease in the number of pathogenic bacteria on masks that have been sterilized using UV light at 15 minutes, 30 minutes, 45 minutes as in table 1. The decrease in the number of pathogenic bacteria increases along with the longer exposure time. This can be seen at 45 minutes of irradiation, the number of pathogenic bacteria is reduced more when compared to the irradiation time of 15 minutes and 30 minutes. The colony number of pathogenic bacteria which are *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* was compared before and after UV light exposures and analyzed with Mann Whitney test.

Table 2.
Colony Number of Pathogen Bacteria

Colony number of	Swab Pre	Swab Post	Swab Pre	Swab Post	Swab Pre	Swab Post
	15 minutes UV		**30 minutes UV**		**45 minutes UV**	
S. aureus	2	0	8	0	30	0
	P= 0.317		P= 0.034		P=0.037	
E.coli	0	0	1	0	0	0
	P= 1.000		P= 0.317		P= 1.000	
P. aeruginosa	2	0	1	0	0	0
	P = 0.114		P= 0.317		P= 1.000	

It was found the number colony of *Staphylococcus aureus* has decreased significantly for 30 minutes (P=0.034) and 45 minutes exposures (P= 0.037); however, the colony number of another pathogen bacterial also decreased but not statistically significant. This could also happening because not many colony numbers that found before the exposure. Other bacteria are normal flora such as *Staphylococcus epidermis*, *Pediococcus pentosaceus*, and *Micrococcus luteus*.

Figure 1. Pathogenic bacteria growth in on Blood Agar, Mc Konkey and Nutrient Agar

UV radiation could induce single and also double DNA strand breaks significantly [9]. If double DNA strand breaks occur, it can lead to the loss of genetic material [10]. The amount of surface pathogen inactivation is directly proportional to the dose of UV radiation, with dosage being defined as the product of intensity (W/m2) and exposure duration(s). UV radiation is a relatively simple method of decontamination that causes minimal

damage to the respirator and avoids the use of irritating chemicals. A recent CDC summary, suggests that a dose of at least 1 Jcm of UV-C is required to decontaminate FFR. Yang et al. found that there was a significant reduction in the number of bacteria colonies sampled from different surfaces after UVC irradiation for 15 min within 1 meter gap[11]. UV disinfection using PX UV device could decrease the bacterial contamination measured in colony-forming units (CFU) by 78.4% [12]. UVC radiation at 253.7 nm for 2 minutes of exposure could achieve a reduction of five logarithms from the initial inoculum of *S. aureus*, *P. aeruginosa*, *E. coli*, *B. subtilis*, and C. *albicans* (reduction>99.999%) [13].

Ultraviolet germicidal irradiation at 254 nm was also found could be effective to decontaminating H1N1 influenza, which significant reductions in influenza viability (=3log) were observed on Ultraviolet germicidal irradiation treated facepieces and straps[14]. Lorre et al. also found that ultraviolet germicidal irradiation at 254 nm satisfactorily decontaminated the 3M 1860s and 1870 FFRs as measured by a virus culture method [7]. Another study also appeared give similar results decontamination technologies using ultraviolet germicidal irradiation at 254 nm provided 4-log reduction of viable H1N1 virus [15].

Ultraviolet germicidal irradiation could potentially be used to disinfect disposable respirators. However, it is also important to understand how ultraviolet germicidal irradiation affects the respirator material [16]. In the previous study, a single cycle or three cycles of lower doses of Ultraviolet germicidal irradiation on respirators found that the penetration and resistance were not significantly changed [17].

Ultraviolet irradiation has big potential to decontaminated bacterial on KN95 mask, especially during outbreaks of airborne or droplet borned infectious diseases which could lead many hospitals are running dangerously low on these protective devices. However, this study is limited because we could not count the ultraviolet doses that was used in various time lengths of exposure. We also did not observe the effect of ultraviolet radiation on the mask respirators. Further study is needed to observe that.

CONCLUSION

The results of this study indicate that UV radiation for 30 and 45 minutes can be effective in decontaminating pathogen bacterial. However further study needs to investigate the effect of UV radiation on filtration mask performance so it would not interfer mask effectiveness. Nevertheless, KN95 mask should still used only once, when there is no lack of supply.

CONCLUSION

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REFERENCES

[1] J. Whitworth, “COVID-19: a fast evolving pandemic,” Transactions of The Royal Society of Tropical Medicine and Hygiene, vol. 114, no. 4, pp. 241–248, Apr. 2020, doi: 10.1093/trstmh/traa025.

[2] N. van Doremalen et al., “Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1,” N Engl J Med, vol. 382, no. 16, pp. 1564–1567, Apr. 2020, doi: 10.1056/NEJMc2004973.

[3] N. Sharma, Z. Hasan, A. Velayudhan, E. M. A., D. K. Mangal, and S. D. Gupta, “Personal Protective Equipment: Challenges and Strategies to Combat COVID-19 in India: A Narrative Review,” Journal of Health Management, vol. 22, no. 2, pp. 157–168, Jun. 2020, doi: 10.1177/0972063420935540.

[4] G. Kampf, D. Todt, S. Pfaender, and E. Steinmann, "Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents," Journal of Hospital Infection, vol. 104, no. 3, pp. 246–251, Mar. 2020, doi: 10.1016/j.jhin.2020.01.022.

[5] T. Lewis, "Infection prevention and control team. Policy on cleaning and disinfection of equipment, surfaces, environment and skin." NorthBeccles: ECCH, 2013, [Online]. Available: https://www.ecch.org/media/1128/cleaning-and-disinfection-of-equipment-surfaces-environment-and-skin-policy-2016-1.pdf.

[6] D. J. Viscusi et al., "Impact of Three Biological Decontamination Methods on Filtering Facepiece Respirator Fit, Odor, Comfort, and Donning Ease," Journal of Occupational and Environmental Hygiene, vol. 8, no. 7, pp. 426–436, Jul. 2011, doi: 10.1080/15459624.2011.585927.

[7] M. B. Lore, B. K. Heimbuch, T. L. Brown, J. D. Wander, and S. H. Hinrichs, "Effectiveness of Three Decontamination Treatments against Influenza Virus Applied to Filtering Facepiece Respirators," The Annals of Occupational Hygiene, Aug. 2011, doi: 10.1093/annhyg/mer054.

[8] D. T. Weaver, et al., "UV Sterilization of Personal Protective Equipment with Idle Laboratory Biosafety Cabinets During the COVID-19 Pandemic," Occupational and Environmental Health, preprint, Mar. 2020. doi: 10.1101/2020.03.25.20043489.

[9] A. J. Jinia et al., "Review of Sterilization Techniques for Medical and Personal Protective Equipment Contaminated With SARS-CoV-2," IEEE Access, vol. 8, pp. 111347–111354, 2020, doi: 10.1109/ACCESS.2020.3002886.

[10] R. P. Rastogi, Richa, A. Kumar, M. B. Tyagi, and R. P. Sinha, "Molecular Mechanisms of Ultraviolet Radiation-Induced DNA Damage and Repair," Journal of Nucleic Acids, vol. 2010, pp. 1–32, 2010, doi: 10.4061/2010/592980.

[11] J.-H. Yang, U.-I. Wu, H.-M. Tai, and W.-H. Sheng, "Effectiveness of an ultraviolet-C disinfection system for reduction of healthcare-associated pathogens," Journal of Microbiology, Immunology and Infection, vol. 52, no. 3, pp. 487–493, Jun. 2019, doi: 10.1016/j.jmii.2017.08.017.

[12] I. Hosein, R. Madeloso, W. Nagaratnam, F. Villamaria, E. Stock, and C. Jinadatha, "Evaluation of a pulsed xenon ultraviolet light device for isolation room disinfection in a United Kingdom hospital," American Journal of Infection Control, vol. 44, no. 9, pp. e157–e161, Sep. 2016, doi: 10.1016/j.ajic.2016.01.044.

[13] A. Guridi, E. Sevillano, I. de la Fuente, E. Mateo, E. Eraso, and G. Quindós, "Disinfectant Activity of A Portable Ultraviolet C Equipment," IJERPH, vol. 16, no. 23, p. 4747, Nov. 2019, doi: 10.3390/ijerph16234747.

[14] D. Mills, D. A. Harnish, C. Lawrence, M. Sandoval-Powers, and B. K. Heimbuch, "Ultraviolet germicidal irradiation of influenza-contaminated N95 filtering facepiece respirators," American Journal of Infection Control, vol. 46, no. 7, pp. e49–e55, Jul. 2018, doi: 10.1016/j.ajic.2018.02.018.

[15] B. K. Heimbuch et al., "A pandemic influenza preparedness study: Use of energetic methods to decontaminate filtering facepiece respirators contaminated with H1N1 aerosols and droplets," American Journal of Infection Control, vol. 39, no. 1, pp. e1–e9, Feb. 2011, doi: 10.1016/j.ajic.2010.07.004.

[16] W. G. Lindsley et al., "Effects of Ultraviolet Germicidal Irradiation (UVGI) on N95 Respirator Filtration Performance and Structural Integrity," Journal of Occupational and Environmental Hygiene, vol. 12, no. 8, pp. 509–517, Aug. 2015, doi: 10.1080/15459624.2015.1018518.

[17] M. S. Bergman, D. J. Viscusi, B. K. Heimbuch, J. D. Wander, A. R. Sambol, and R. E. Shaffer, "Evaluation of Multiple (3-Cycle) Decontamination Processing for Filtering Facepiece Respirators," Journal of Engineered Fibers and Fabrics, vol. 5, no. 4, p. 155892501000500, Dec. 2010, doi: 10.1177/155892501000500405.