

Assessment of Bacterial Contamination and Health Risks Associated With Prolonged Use of Face Masks in Industry Settings

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ABSTRACT

Face masks are a critical component of Personal Protective Equipment (PPE) for occupational safety and health management. Nevertheless, prolonged usage of face masks may expose employees to biological contaminants, such as bacteria, which accumulate on the inner surface of the mask and pose potential health risks. This study involved 216 participants employed by a statutory institution in Malaysia. The participants were assigned to wear three types of face masks: cotton, surgical, and Korean filters for durations of four and eight hr during their respective work shifts, which varied across roles such as office workers, trainers, and cleaners. Bacterial isolates from the masks were analyzed using the MALDI-TOF method for species identification. Twelve bacterial species were successfully identified, including *Staphylococcus hominis*, *Staphylococcus epidermidis*, *Staphylococcus ureilyticus*, *Bacillus velezensis*, *Dermacoccus nishinomiyaensis*, *Bacillus licheniformis*, *Acinetobacter variabilis*, *Micrococcus luteus*, *Bacillus pumilus*, *Bacillus cereus*, *Sporosarcina luteola*, and *Staphylococcus aureus*. Most of these species are part of the normal human microbiota but have the potential to act as opportunistic pathogens. Additionally, other bacterial species, particularly spore-forming ones, may have originated from the work environment. To mitigate microbial risks, individuals performing strenuous physical tasks or those with compromised immunity are advised to avoid reusing face masks and to replace them every four hr.

Key words: Bacterial contamination, face masks, microbial air quality, occupational safety and health

INTRODUCTION

Personal Protective Equipment (PPE) represents the final tier in the hierarchy of safety and health controls, serving as a critical safeguard for employees. The importance of face mask (FM) usage among workers has been long established, with numerous studies conducted to advance occupational safety and health practices (OSHA, 1994). Following the onset of the COVID-19 pandemic, authorities have recommended expanded use of FMs across various employment sectors during working hr as a preventive measure against SARS-CoV-2 transmission and the spread of contaminated droplets (Liang *et al.*, 2020). However, extended use of FMs may lead to the accumulation of biological pollutants, such as bacteria, on the inner surface, potentially posing health risks to employees (Delanghe *et al.*, 2021). Such risks may negatively impact worker productivity and harm an organization's reputation (Sulemana & Ngah, 2012; Zaied *et al.*, 2012).

During the COVID-19 pandemic, face masks (FM) were identified as one of the most effective measures to prevent the transmission of SARS-CoV-2 and respiratory droplets. Key strategies for controlling the spread of COVID-19 included mask usage in group settings, adherence to physical distancing practices, and the incorporation of natural ventilation systems supplemented by air conditioning. However, research on the effectiveness of masks, particularly concerning cleanliness, proper usage, and disposal, remains in its early stages. This issue has been highlighted as a significant concern by the World Health Organization (WHO) (Park *et al.*, 2022).

While some studies have investigated bacterial or viral contamination of masks in controlled experimental and clinical environments, limited research exists on the extent of microbial contamination during real-world use (Leung *et al.*, 2020; Ueki *et al.*, 2020). Understanding the types of microorganisms, including bacteria, that can contaminate masks, their survival duration on various mask materials, and the associated infection risks is crucial (Park *et al.*, 2022). Prolonged mask use during working hr can create high levels of moisture on the inner surface of the mask, leading to discomfort for some employees. This humidity can facilitate bacterial accumulation or mask contamination. As a result, normal human microbiota from the skin may migrate to the respiratory system, potentially posing health risks.

Under normal conditions, the human microbiota residing on and within the body plays a vital role in protecting against harmful pathogens and supporting the proper functioning of bodily systems. Activities such as breathing, talking, coughing, and sneezing can release respiratory droplets containing bacteria. Disruptions in the balance of the normal flora may enable opportunistic pathogens to emerge, particularly when a member of the microbiota enters an area of the body it does not typically

Article History

Accepted: 9 February 2026
First version online: 31 March 2026

Cite This Article:

Osman, B., Mahmud, H., Mazlan, S.M. & Aqma, W.S. 2026. Assessment of bacterial contamination and health risks associated with prolonged use of face masks in industry settings. *Malaysian Applied Biology*, 55(1): 19-27. <https://doi.org/10.55230/mabjournal.v55i1.3405>

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inhabit, potentially leading to infections and exacerbating disease severity (Stevens *et al.*, 2021). Bacteria can adapt rapidly to environmental changes, including those induced by the immune response of an infected host. This adaptability can transform otherwise harmless bacteria into life-threatening pathogens (Vezzulli *et al.*, 2020).

Physical factors, such as temperature and humidity, are critical determinants of bacterial growth (Xiong *et al.*, 2017; Qiu *et al.*, 2022). The warm, humid microenvironment created by mask-wearing, coupled with moisture from respiration, provides favorable conditions for bacterial proliferation (Teo, 2021). Bacteria naturally present on the skin, as well as those in respiratory droplets released during activities such as breathing and speaking, can become trapped on the inner surface of the mask. If masks are not regularly cleaned or replaced, these bacteria may multiply and colonize the mask, leading to an increased microbial load on its surface (Yousefimashouf *et al.*, 2023).

Bacterial colonization on masks can result from a combination of environmental factors, personal hygiene practices, and the inherent characteristics of the bacteria. Under certain conditions, these bacteria may play beneficial roles in maintaining health. However, colonization can become detrimental when pathogenic bacteria proliferate, potentially leading to illnesses or skin irritation. Moreover, the type of face mask material significantly influences bacterial colonization. Some materials retain moisture more effectively, creating an environment conducive to bacterial growth. The mask's design also plays a role, as factors such as airflow and moisture retention can impact the patterns of bacterial colonization.

A critical consideration in protecting employees from outdoor air pollutants through the use of face masks (FM) during work is addressing bacterial contamination on the inner surface of the masks in the context of occupational safety and health. This study aimed to identify the bacterial species present on three types of face masks: cotton, surgical, and Korean filters (KF) worn by employees in different job roles (office workers, trainers, and cleaners) for durations of four and eight hr. The study included office workers, encompassing clerks in public administration, receptionists, technicians, executive and managers. Trainers were workers drawn from the departments of training, consulting, and research and development. Cleaners are in charge of keeping the workplace hygienic and clean, which includes regular indoor cleaning and disinfection, waste management, and maintenance of common areas and facilities.

In Malaysia, full-time employees are generally required to work eight hr per day or 45 hr per week, as stipulated by the Employment Act 1955. This study aimed to investigate whether prolonged face mask use, defined as wear durations of 4 and 8 hr based on three job roles, leads to the accumulation of biological contaminants on the inner surface of the mask, with potential implications for workers' health.

MATERIALS AND METHODS

Study Participants: A total of 216 healthy individuals from a statutory body institution in Malaysia participated in this study. The cohort comprised office workers, trainers, and cleaners, with 56% male and 44% female participants. Their ages ranged from 27 to 60 years, and all participants were confirmed to be in good health at the time of the study. The study protocol was reviewed and approved by the Ethical Committee of the National Institute of Occupational Safety and Health (NIOSH), Malaysia (Ref. No.: 243042-U).

Samples: Three types of face masks were selected for this study: cotton (Figure 1), surgical (Figure 2), and Korean filter (KF) masks (Figure 3). These mask types were chosen because they are commonly used by employees and the general public as part of public health measures during global pandemics (Cowling *et al.*, 2010; Delanghe *et al.*, 2021; Wang *et al.*, 2023). All samples were collected between July 2022 and February 2023.



Fig. 1. Cotton face mask



Fig. 2. Surgical face mask



Fig. 3. KF face mask

A generic cotton mask was used in this study. Cotton masks are composed of multiple layers of woven fabric and are washable and reusable, making them an environmentally friendly option. Their filtration efficiency varies with fabric weave and layer number, typically ranging from 30% to 60%. Although they provide lower protection than KF94 or surgical masks, their comfort, affordability, and reusability make them suitable for prolonged use in non-medical settings.

A Medicos three-ply non-woven polypropylene surgical mask was used in this study. Surgical masks offer moderate filtration efficiency, removing approximately 60–80% of airborne particles $\geq 0.3 \mu\text{m}$, and are widely used due to their affordability and availability. At last, a NOVID-brand KF94 mask was used in this study. KF94 masks meet South Korean performance standards and filter at least 95% of airborne particles when properly fitted. Their multilayer non-woven construction and adjustable nose bridge improve facial seal and reduce leakage, making them suitable for higher-risk environments.

Study designs

Bacteria sampling

Each participant wore three types of face masks (FM): cotton, surgical, and Korean filter (KF) for a duration of 4 hr (Delanghe *et al.*, 2021) and eight hr, according to their job roles (office workers, trainers, and cleaners). Prior to wearing the new and unused masks, each participant's body temperature was recorded, and the masks used were new and unused. After completing the designated mask-wearing period, participants placed the masks in sterile plastic zip-lock bags provided for this purpose. The samples were then promptly submitted to the laboratory to ensure they were analyzed either on the same day or within 24 hr of collection.

Bacterial sampling from the inner surface of the face masks was initiated by marking a targeted area (2 cm x 2 cm) on the mask (Figure 4). A sterile cotton-tipped swab was moistened with 0.85% saline solution and used to swab the designated area of the mask. To determine the baseline bacterial load or serve as a control, clean, unused cotton, surgical, and KF face masks were also sampled and plated for comparison (Loeb *et al.*, 2009; Delanghe *et al.*, 2021).

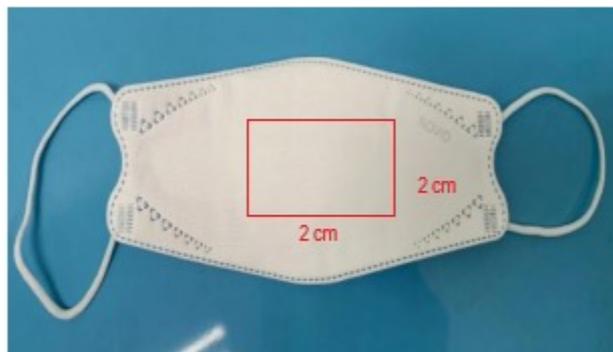


Fig. 4. Marking the target area on the FM

Sub-culture and isolation of bacteria

Bacteria were transferred onto tryptic soy agar (TSA) plates using the streaking technique (two plates per sample) and incubated at 37°C for 24–48 hr. Subcultures of colonies exhibiting different morphologies were then transferred to new TSA plates and incubated for an additional 24–48 hr at 37°C. Two primary methods were used for bacterial identification: morphological observations and physiological characteristics. Morphological observations included the identification of Gram-positive Bacillus group bacteria, Gram-positive coccus group bacteria, and Gram-negative Coccus group bacteria. For physiological characteristics, several biochemical tests were conducted, including Gram staining, catalase testing, and oxidase testing (Jha, 2020). Following these procedures, pure bacterial colonies were subjected to MALDI-TOF analysis for species identification.

RESULTS

Identification of Bacteria from Surgical, Cotton, and KF face masks

A total of 25 bacterial isolates were obtained from the bacterial identification process conducted on three types of face masks: surgical, cotton, and Korean filter (KF) masks (Table 1). These isolates were categorized into three groups of Gram bacteria: Gram-positive cocci, Gram-positive bacilli, and Gram-negative bacilli.

Of the 25 bacterial isolates, only 12 were successfully identified to the species level (Table 2). These species included

Staphylococcus hominis, *Staphylococcus epidermidis*, *Staphylococcus ureilyticus*, *Bacillus velezensis*, *Dermacoccus nishinomiyaensis*, *Bacillus licheniformis*, *Acinetobacter variabilis*, *Micrococcus luteus*, *Bacillus pumilus*, *Bacillus cereus*, *Sporosarcina luteola*, and *Staphylococcus aureus*.

Table 1. The percentage of bacteria species found on the facial side surgical face masks, cotton face masks, and KF face masks based on three job roles

Bacterial species		Surgical face mask		Cotton face mask		KF face mask	
		4 hr	8 hr	4 hr	8 hr	4 hr	8 hr
<i>Staphylococcus hominis</i>	Office workers	22 %	16 %	8 %	15 %	12 %	16 %
	Trainers	33 %	16 %	22 %	16 %	22 %	12 %
	Cleaners	18 %	9 %	27 %	0 %	18 %	9 %
<i>Staphylococcus epidermidis</i>	Office workers	27 %	37 %	32 %	17 %	25 %	26 %
	Trainers	43 %	29 %	33 %	29 %	22 %	41 %
	Cleaners	9 %	45 %	36 %	45 %	18 %	45 %
<i>Staphylococcus ureilyticus</i>	Office workers	15 %	14 %	9 %	12 %	9 %	14 %
	Trainers	10 %	10 %	16 %	4 %	12 %	8 %
	Cleaners	0 %	0 %	9 %	0 %	46 %	0 %
<i>Bacillus velezensis</i>	Office workers	10 %	14 %	18 %	17 %	10 %	12 %
	Trainers	8 %	8 %	9 %	14 %	10 %	12 %
	Cleaners	18 %	0 %	9 %	0 %	18 %	27 %
<i>Dermacoccus nishinomiyaensis</i>	Office workers	12 %	5 %	7 %	12 %	11 %	4 %
	Trainers	12 %	4 %	6 %	12 %	6 %	6 %
	Cleaners	9 %	0 %	9 %	0 %	0 %	0 %
<i>Bacillus licheniformis</i>	Office workers	8 %	6 %	6 %	6 %	6 %	4 %
	Trainers	8 %	8 %	4 %	6 %	2 %	2 %
	Cleaners	0 %	9 %	18 %	0 %	0 %	0 %
<i>Acinetobacter variabilis</i>	Office workers	13 %	8 %	12 %	13 %	16 %	10 %
	Trainers	8 %	18 %	10 %	10 %	12 %	20 %
	Cleaners	36 %	9 %	0 %	9 %	18 %	18 %
<i>Micrococcus luteus</i>	Office workers	11%	9 %	10 %	8 %	16 %	13 %
	Trainers	4 %	10 %	10 %	16 %	6 %	8 %
	Cleaners	0 %	9 %	9 %	18 %	9 %	9 %
<i>Bacillus pumilus</i>	Office workers	0 %	0 %	0 %	0 %	0 %	0 %
	Trainers	2 %	0 %	0 %	0 %	0 %	0 %
	Cleaners	0 %	0 %	0 %	0 %	0 %	0 %
<i>Bacillus cereus</i>	Office workers	0 %	0 %	0 %	0 %	0 %	0 %
	Trainers	0 %	2 %	0 %	0 %	0 %	0 %
	Cleaners	0 %	0 %	0 %	9 %	0 %	0 %
<i>Sporosarcina luteola</i>	Office workers	10 %	6 %	9 %	10 %	0 %	10 %
	Trainers	6 %	8 %	10 %	22 %	0 %	14 %
	Cleaners	0 %	0 %	9 %	18 %	0 %	9 %
<i>Staphylococcus aureus</i>	Office workers	13 %	11 %	13 %	13 %	8 %	11 %
	Trainers	8 %	12 %	20 %	10 %	8 %	10 %

Staphylococcus epidermidis is a Gram-positive coccus, typically arranged in grape-like clusters. Its colony morphology features milky-colored, small, round shapes with a moist texture (Table 2). This bacterium is a normal component of the human microbiota, commonly found on the skin in various microenvironments, including moist, dry, sebaceous, and foot regions, as well as on mucous membranes (Byrd *et al.*, 2018). On healthy human skin, *Staphylococcus epidermidis* is one of the most prevalent bacterial colonizers and is typically considered harmless (Brown & Horswill, 2020). As a symbiotic organism, it contributes to skin homeostasis and uses colonization resistance to prevent opportunistic infections (Severn & Horswill, 2023).

DISCUSSION

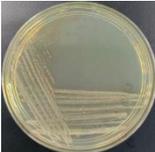
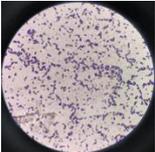
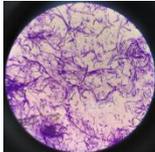
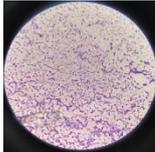
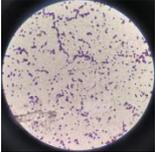
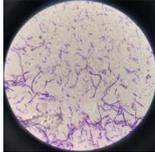
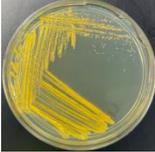
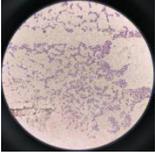
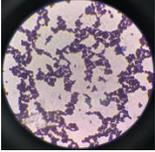
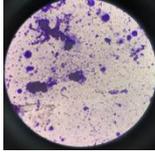
Based on Table 1, *Staphylococcus epidermidis* exhibited the highest percentage distribution of bacteria across all three types of face masks (surgical, cotton & KF) worn by office workers, trainers, and cleaners for both 4-hr and 8-hr durations. It was followed by *Staphylococcus ureilyticus* and *Acinetobacter variabilis*.

However, once *Staphylococcus epidermidis* enters the human body, it can become virulent and act as an important opportunistic pathogen. The production of biofilm is a critical factor in its initial adhesion and primary attachment to host tissues, enabling it to overcome host defenses by forming multicellular structures (Vuong & Otto, 2002; Otto, 2009). Additionally, the production of various exotoxins and endotoxins further contributes to its virulence, triggering immune responses and exacerbating its pathogenicity (Demiselle *et al.*, 2023). *Staphylococcus epidermidis* has the potential to cause both localized and systemic infections in the human body.

Staphylococcus epidermidis also has the potential to cause significant health consequences and is among the most frequent

causes of nosocomial infections in hospitals. It is the primary bacterium responsible for nosocomial bloodstream infections, heart infections, and infections of the nose, throat, eyes, and ears (Vuong & Otto, 2002). This bacterial species is a major contributor to bloodstream infections associated with catheter use (Demiselle *et al.*, 2023). Patients may present with systemic symptoms such as hypotension, fever, and other sepsis-related signs (Ziebuhr *et al.*, 2006; Rogers *et al.*, 2009; Landemaine *et al.*, 2023;). Other common diseases caused by *Staphylococcus epidermidis* include infectious endocarditis (Lalani *et al.*, 2006) and shunt infections (Rogers *et al.*, 2009).

Table 2. Bacterial species growth on TSA and Gram-staining

Bacterial species	Growth at TSA	Gram-staining	Bacterial species	Growth at TSA	Gram-staining
<i>Staphylococcus epidermidis</i>			<i>Sporosarcina luteola</i>		
<i>Staphylococcus ureilyticus</i>			<i>Staphylococcus aureus</i>		
<i>Acinetobacter variabilis</i>			<i>Bacillus licheniformis</i>		
<i>Staphylococcus hominis</i>			<i>Bacillus cereus</i>		
<i>Dermacoccus nishinomiyaensis</i>			<i>Bacillus pumilus</i>		
<i>Micrococcus luteus</i>			<i>Bacillus velezensis</i>		

Next, 46% of cleaner workers' KF face masks tested positive for *Staphylococcus ureilyticus* after 4 hr. *Staphylococcus ureilyticus* is a Gram-positive coccus bacterium. Its colony morphology is characterized by milky-colored, small, round shapes with a moist texture. The antibiotic resistance and biofilm-forming ability of the isolates suggest they can persist on mask surfaces (Bitolitioli *et al.*, 2025). Among cleaners, prolonged mask use may increase exposure to these resilient bacteria. Like *Staphylococcus epidermidis*, this bacterium is considered part of the normal human microbiota. While it has traditionally been recognized as a component of human skin flora, recent studies have identified it as a common causative agent of infections (Kwon *et al.*, 2022).

In response to the rise in nosocomial infections caused by *Staphylococcus ureilyticus* resistant to antibiotics, this bacterium has become more pathogenic and resistant to antimicrobial treatments through the formation of biofilms (Tuon *et al.*, 2023). This biofilm production is a key factor contributing to nosocomial bloodstream infections (Jain *et al.*, 2011; Singh *et al.*, 2016). Bloodstream infections are among the most dangerous conditions associated with healthcare, exhibiting high rates of morbidity and mortality (McNamara *et al.*, 2018).

In addition, *Acinetobacter variabilis* is a Gram-negative bacillus with pale yellow colonies, medium-sized round colonies with smooth edges, and a moist texture on TSA. This bacterial species is occasionally found in water and soil and has also been detected on the skin of healthy individuals (Alsan & Klompas, 2010). For healthy individuals, *Acinetobacter* species pose minimal risk. However, individuals with diabetes, chronic lung diseases, or compromised immune systems are particularly susceptible to *Acinetobacter* infections, which can lead to severe complications and, in critically ill patients, may contribute to mortality (Virginia Department of Health, 2018).

Additionally, other bacterial species identified include *Staphylococcus hominis*, *Dermacoccus nishinomiyaensis*, *Micrococcus luteus*, *Sporosarcina luteola*, and *Staphylococcus aureus*, all of which are considered part of the normal human microbiota.

Numerous studies have linked *Staphylococcus aureus* colonization to the pathophysiology of acne, with its superantigen effect contributing to flare-ups of eczema (Khorvash *et al.*, 2012). However, these bacteria can also act as opportunistic pathogens in immunocompromised individuals, including *Bacillus licheniformis* (Haydushka *et al.*, 2012). Furthermore, species from the *Bacillus* group, such as *Bacillus cereus*, are considered volatile human pathogens due to their ability to release toxins associated with infections of the eye, respiratory system, wounds, and gastrointestinal illnesses (Bottone, 2010; McDowell *et al.*, 2023).

However, *Bacillus pumilus* is not considered part of the normal human microbiota in the gastrointestinal tract (GIT), although it can be found in the human GIT, as well as in fermented foods, water, air, soil, and decomposing plant and animal tissues (Reyes-Cortes *et al.*, 2021). In contrast, *Bacillus velezensis* is non-pathogenic and serves as a key component of microbial biocontrol agents, effectively eradicating plant-pathogenic bacteria while being environmentally benign (Rabbee *et al.*, 2023).

Based on the results of the bacterial species identified in this study, it is evident that most of the bacteria are part of the normal human microbiota. Under normal conditions, these bacteria play a role in maintaining the balance of the complex ecosystem within the human host. However, prolonged use of face masks (FM) while performing work-related tasks may cause discomfort, particularly for employees. Changes in physical factors such as temperature and humidity on the face-side of the FM, resulting from breathing difficulties and excessive sweating around the nostrils and mouth, and difficulties and excessive sweating created by the employees' nostrils and mouth (Purushothaman *et al.*, 2021; Gyapong *et al.*, 2022), can facilitate bacterial colonization and the formation of bacterial biofilms (Kranjec *et al.*, 2021).

The isolated microbes may behave as opportunistic infections or spread to immunocompromised people, even though they are normally a part of the normal human microbiota and present no risk to healthy people. To lower any transmission hazards, it is advised to practice good mask hygiene, use masks for the right amount of time, and replace or clean them on a regular basis.

Spore-forming bacteria such as *Bacillus licheniformis*, *Bacillus cereus*, *Bacillus pumilus*, and *Bacillus velezensis* are microorganisms characterized by their ability to produce spores, which are resilient, dormant structures that allow them to survive for extended periods (Amador-Espajo *et al.*, 2014; Cho & Chung, 2020). The presence of these bacteria in this study may be attributed to their work environment or contamination from food sources containing bacterial spores, which could be released and subsequently trapped on the face-side of the face masks worn by employees.

The identification of spore-forming *Bacillus* species may be associated with occupational exposure within the statutory body, including office-based, training, and cleaning activities, as well as potential contamination from spore-containing food sources. These spores may subsequently become trapped on the face-facing surface of worn masks. In addition, employees work in an air-conditioned indoor environment during working hr, which may influence airflow and the accumulation of airborne spores.

Table 3. Statistical analysis results based on job roles and exposure times (4 hr & 8 hr) for each type of face mask

P-value	Surgical face mask			Cotton Mask			KF Mask		
	Trainers	Office workers	Cleaners	Trainers	Office workers	Cleaners	Trainers	Office workers	Cleaners
	0.191	0.108	0.566	0.0899	0.768	0.000366	0.798	0.667	0.00711

P-The value is significant when $p < 0.05$

Based on Table 3, based on job roles and exposure times (4 hr & 8 hr) for each type of face mask, the correlation test revealed no significant differences ($p > 0.05$). The only exception was observed among cleaners wearing cotton and KF face masks, where a significant difference was noted ($p < 0.05$). The increased physical activity of cleaners, who are generally more energetic than trainers and office workers, may contribute to this outcome. The movement involved in cleaning tasks elevates the employees' respiration rate and energy consumption, leading to greater air trapping, increased moisture retention, and enhanced stickiness, all of which can promote bacterial growth (Teo, 2021).

The correlation test between the three types of face masks showed no significant differences ($p > 0.05$). This can be attributed to the materials and filtration efficiency of the face masks, which influence their ability to trap and filter bacteria. The three types of face masks used in this study are made from different materials, ranging from simple fabrics like cotton to surgical masks and medical-grade respirators. The differences in materials and pore sizes among these face masks affect their ability to trap moisture and regulate the flow of bacteria in and out. Additionally, the fit and seal of the face mask on the employee's face are critical for effective filtration, as gaps or inconsistencies can allow air and microbes to bypass the material (Wang *et al.*, 2023). Environmental factors also play a significant role in bacterial contamination, as exposure to high concentrations of airborne microbes can increase the risk of contamination (Cho *et al.*, 2019).

According to the study, the bacterial can accumulate on the inner surfaces of face masks worn by employees, with differences seen across job roles and mask use durations (4 & 8 hr). Some bacteria were antibiotic-resistant and capable of forming biofilms, suggesting they may persist on masks and could pose a risk to immunocompromised individuals. Job roles, mask type, and fit may affect bacterial buildup. Limitations include the lack of participant facial or respiratory swabs, no detailed assessment of workplace environments, and no environmental sampling, which may affect interpretation. Future studies should include these measures to better understand microbial exposure in occupational settings.

CONCLUSION

This study investigates bacterial contamination on various types of face masks (cotton, surgical, and KF masks) worn by workers during job-related tasks. The findings reveal that most bacteria identified are common components of the human microbiota, which can occasionally become opportunistic pathogens, posing potential risks to individuals with compromised immune systems. Additionally, spore-forming bacteria, such as *Bacillus* species, may originate from workplace environments, with their resilience contributing to their survival on masks. The research emphasizes that physical factors, such as heat and humidity generated by prolonged mask use, encourage bacterial growth and biofilm formation, particularly among workers engaged in physically demanding tasks. While these bacteria are typically part of the human microbiota, they may still pose health risks in

certain conditions by causing infections.

This study offers a detailed analysis of bacterial contamination on face masks in occupational settings, accounting for variables such as job roles and mask usage duration. To reduce the risk of microbial infections, individuals engaged in physically demanding work or with compromised immune systems should replace masks every four hr instead of reusing them. It addresses a gap in existing research, which has largely focused on laboratory or clinical environments.

ACKNOWLEDGEMENTS

The authors express their gratitude to the team at the National Institute of Occupational Safety and Health (NIOSH), Malaysia, and the Department of Biological Sciences and Biotechnology, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, for their support. All authors contributed to the interpretation of experimental data, as well as the writing and review of the manuscript.

ETHICAL STATEMENT

This study was approved by the Ethical Committee of the National Institute of Occupational Safety and Health (NIOSH), Malaysia, approval number (Ref. No.: 243042-U).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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