

ORIGINAL ARTICLE

Use of thin silicone dressings for prolonged use of filtering facepiece respirators: Lessons from the universal community testing programme during the COVID-19

Ka-Huen Yip  | Yuk-Chiu Yip 

School of Health Sciences, Caritas
Institute of Higher Education, Tseung
Kwan O, Hong Kong, China

Correspondence

Yuk-Chiu Yip, School of Health Sciences,
Caritas Institute of Higher Education,
2 Chui Ling Lane, Tseung Kwan O,
New Territories, Hong Kong, China.
Email: jeffreycyip@gmail.com

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Abstract

A universal community testing programme (UCTP) was initiated by the government of the Hong Kong Special Administrative Region of the People's Republic of China, as part of a territory-wide initiative to enhance the control of the coronavirus disease (COVID-19) pandemic, to facilitate the early identification of asymptomatic patients in the community-transmission chain. The authors (who were also engaged in this programme) observed that, at the end of their 6-hour shift, most of the HCPs sustained medical device-related pressure injuries (MDRPI), frequently on their faces, over the bridge of their nose, the upper cheeks, above the ears, lower jaws, and chin that caused pain and erythema. In this study, our team examined whether two different types of dressing (light silicone foam dressing and soft silicone perforated tape dressing) applied on the anatomical locations (including the bridge of the nose, upper cheek, above the ears, and lower jaw) would enable the wearer to pass the quantitative respirator fit testing that was conducted using a PortaCount Pro+ Respirator Fit Tester 8038. We also investigated if any skin reactions occurred after the participants worn the respirator with our applied dressing materials for 240 minutes in a safe laboratory setting. Lastly, we collected the qualitative feedback concerning how the participants felt about the performance of our dressing materials in preventing MDRPI associated with the prolonged use of tight-fitting FFRs. A small convenience sample of HCPs ($n = 24$) who participated in the UCTP was recruited. We randomly selected 12 participants for one type of dressing, and the rest for the second type of dressing. Quantitative fit testing showed an adequate seal of the respirators with the use of both types of thin dressings that were available in the clinical settings. All of the participants except one tolerated the dressings for prolonged use without any report of adverse skin reactions. Our findings may move a step forward in assisting the process of developing feasible pre-emptive skincare practice guidelines to reduce MDRPI during the prolonged use of nanofiber bacterial surgical respirators.

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KEYWORDS

COVID-19, pressure ulcer, respiratory protective devices

Key Messages

- this study demonstrated that the placement of either type of thin dressings (light silicone foam dressing or soft silicone perforated tape dressing) under nanofiber bacterial surgical respirators will not compromise the nanofiber bacterial surgical respirator's facial seal that is necessary to protect HCPs from exposure to SARS-CoV-2 infection
- quantitative fit testing using the PortaCount Pro+ Respirator Fit Tester 8038 showed an adequate seal of the respirators with the use of thin dressings (Biatain and Siltape) that were available in clinical settings
- the great majority of participants tolerated the dressings for prolonged use without any report of adverse skin reactions, such as hyperaemia, itching, pain, and discomfort, at the bridge of the nose, cheeks, and lower jaw

1 | INTRODUCTION

A universal community testing programme (UCTP) was initiated by the government of the Hong Kong Special Administrative Region of the People's Republic of China, as part of a territory-wide initiative to enhance the control of the coronavirus disease (COVID-19) pandemic, to facilitate the early identification of asymptomatic patients in the community-transmission chain. The UCTP was conducted in September 2020 in Hong Kong, and gained widespread support from health care professionals (including nurses). In the UCTP program, nurses are responsible for specimen collection (specifically, the collection of a sample that combined the nasal and throat swabs). Within the premises where the specimen collection procedure was performed, health care practitioners have to adopt infection control measures to prevent the aerosol transmission of severe acute respiratory syndrome coronavirus 2 (SARS-COV-2). Airborne aerosols particles may be generated during coughing or sneezing by the asymptomatic citizens; thus, health care practitioners (HCPs) must perform their duties while wearing disposable filtering facepiece respirators (FFRs; or equivalent equipment, in accordance with the precautions to prevent airborne infection) and a full set of personal protective equipment (PPE; including a face shield) during their service in the community centres (for approximately 6 hours, with a 30-minute break in between the third and fourth hour; Figure 1). The authors (who were also engaged in this program) observed that, at the end of their 6-hour shift, most of the HCPs sustained medical device-related pressure injuries (MDRPI), frequently on their faces, over the bridge of their nose, the upper cheeks, above the ears, lower jaws, and chin that caused pain and erythema (Figure 2). In 2016, the National

Pressure Ulcer Advisory Panel (NPUAP) defined MDRPIs as pressure injuries (PIs) that '*result from the use of devices designed and applied for diagnostic or therapeutic purposes*', remarking that, on the skin, such PIs are inclined to assume '*the pattern or shape of the device*' and '*should be staged using the [NPUAP] staging system*'.¹ In accordance with the National Pressure Injury Advisory Panel (NPIAP), MDRPIs have been broadly discussed and many evidence-based practice guidelines to alleviate



FIGURE 1 Health care providers were required to wear personal protective equipment as part of the universal community testing programme

Throat



Cheekbones from the mask strap



FIGURE 2 Areas of pressure injury after prolonged use of tight-fitting respirators

its incidence in patients, but not in HCPs, have been formulated.²⁻⁴ Nonetheless, there is limited empirical evidence on whether the use of certain thin dressings under a tight-fitting FFR may impair the efficacy of PPE and the safety of HCPs.^{4,5}

This situation engenders a clinically relevant question: ‘Can light silicone foam dressing and soft silicone perforated tape dressing be applied under a respirator (specifically, the NASK Nanofiber Smart Mask – Bactericidal Surgical Respirator) on the face of the wearer to prevent MDRPI for prolonged use while providing sufficient respiratory protection to the healthcare professionals?’ To address this question, a collaborative research project was undertaken. The research team included a practicing nurse consultant who is a certified and experienced wound, ostomy, and continence nurse (WOC nurse) working at a public hospital in Hong Kong, and the remaining members are nurse educators in academia.

When this study was being conducted, the National Institute for Occupational Safety and Health (NIOSH) N95 certified nanofiber bacterial surgical respirator was widely used by the local HCPs⁶; this respirator is a tight-fitting facepiece with high filtering efficiency against airborne particles, and provides protection against airborne infectious diseases.⁷ In this study, our team examined whether two different types of dressing (light silicone foam dressing and soft silicone perforated tape dressing) applied on the anatomical locations (including the bridge of the nose, upper cheek, above the ears, and lower jaw) would enable the wearer to pass the quantitative respirator fit testing that was conducted using a PortaCount Pro + Respirator Fit Tester 8038. We also investigated if any skin reactions occurred after the participants had worn the respirator with our applied dressing materials for

240 minutes. Lastly, we collected qualitative feedback concerning how the participants felt about the performance of our dressing materials in preventing MDRPI associated with the prolonged use of tight-fitting FFRs.

2 | METHODS

This study was conducted at a tertiary education institute between November and December 2020, during which the UCTP was led by the first author (KH). A convenience sample of HCPs ($n = 24$) who participated in the UCTP was recruited. All participants provided written consent for study participation and gave permission for the use of their photographs in this publication. Before enrolment in the study, participants were assessed by the research team (KH and YC) to ensure that there is no impairment of facial skin integrity at baseline. All participants were not found with any history of skin allergy, existing skin breakdown, wound-related damage, bruising, or facial lesions.

The selected dressings in this study must fulfil the following criteria: (a) the design of dressing should serve a protective function for the skin of the wearer from pressure, friction, and moisture; (b) the design should provide wearers a certain level of comfort when the dressing is worn on the face; and (c) the dressing materials should be easy to apply and remove for the users. We selected two types of thin silicone dressings (Biatain and Siltape) that fulfil the above criteria and are available in various clinical settings within the public health care system. The Biatain silicone foam dressing is a non-adherent soft silicone foam dressing with a border that is used to minimise trauma to the facial skin and the bridge of the

nose.⁸ Siltape is a soft silicone perforated tape dressing that prevents skin breakdown from friction and pressure damage.⁹

We randomly selected 12 participants for one type of dressing, and the rest for the second type of dressing. To ensure comfort while maintaining the integrity of the mask seal, we used simple and tailor-made outline to cut out these dressings (Figure 3A). Before the application of the dressing materials to the participants, our team ensured that all participants followed the five-step

procedure for cleaning the face^{10,11} (Figure 4). This procedure facilitates the enhanced fit and sealing of the respirator, which could otherwise be compromised by residues of cream, lotion, or make-up. The dressing template was applied to the skin of the HCPs at anatomical locations, such as the bridge of the nose, cheekbone, and lower jaw (Figure 3B).

The dressings were placed under the edges of the nanofiber bacterial surgical respirator for the prevention of MDRPI on anatomical locations such as the bridge of

Biatain® silicone foam dressing

Siltape®

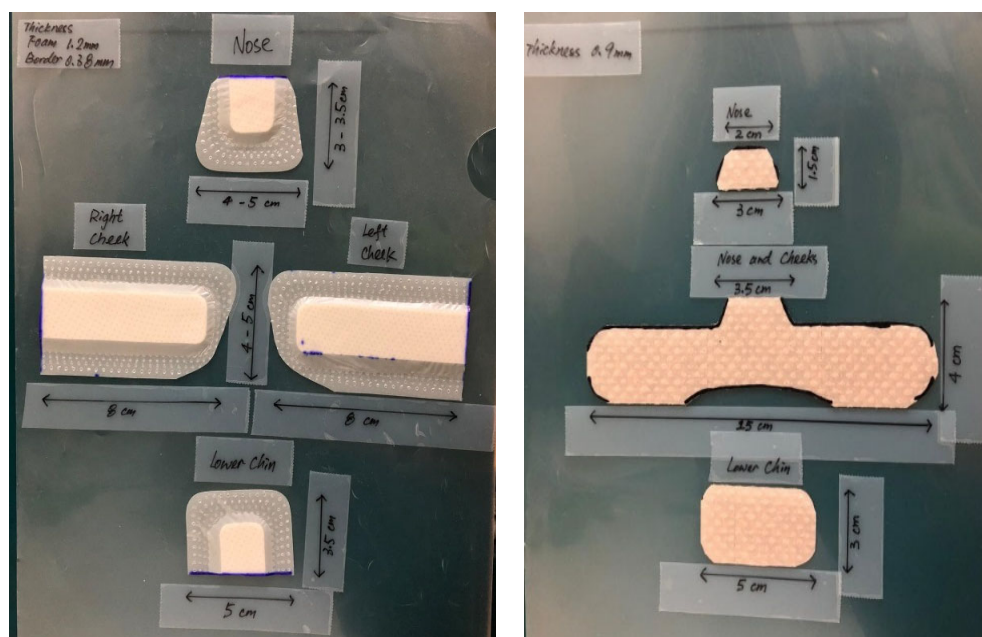


FIGURE 3 (A) The dressing materials were applied to the bridge of the nose, the cheeks under the eyes, and the lower chin where the nanofiber bactericidal surgical respirator was applied. (B) The application of dressing materials on several anatomical locations where pressure injury most likely occurred due to the prolonged use of filtering facepiece respirators (FFRs)



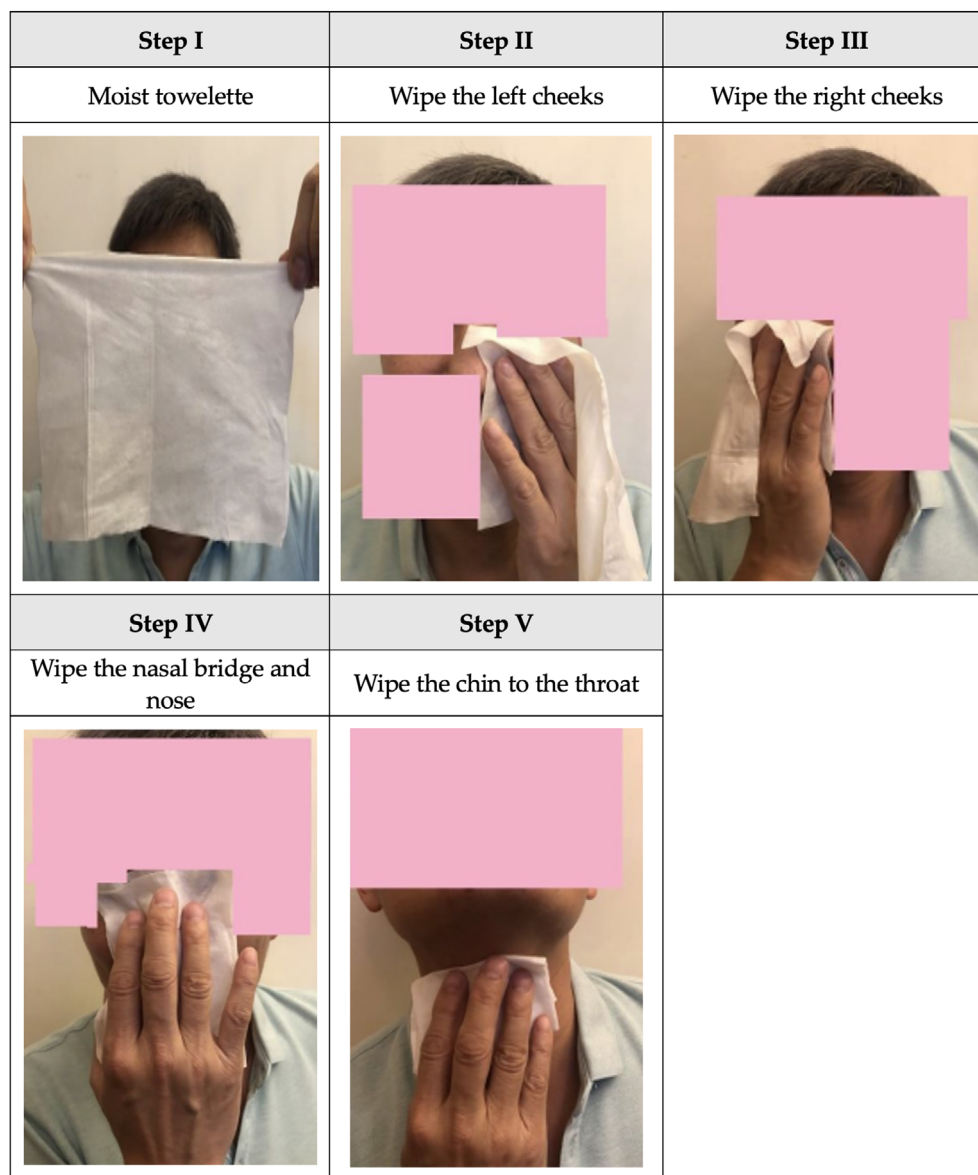


FIGURE 4 Steps on how to clean the face with a moist towelette

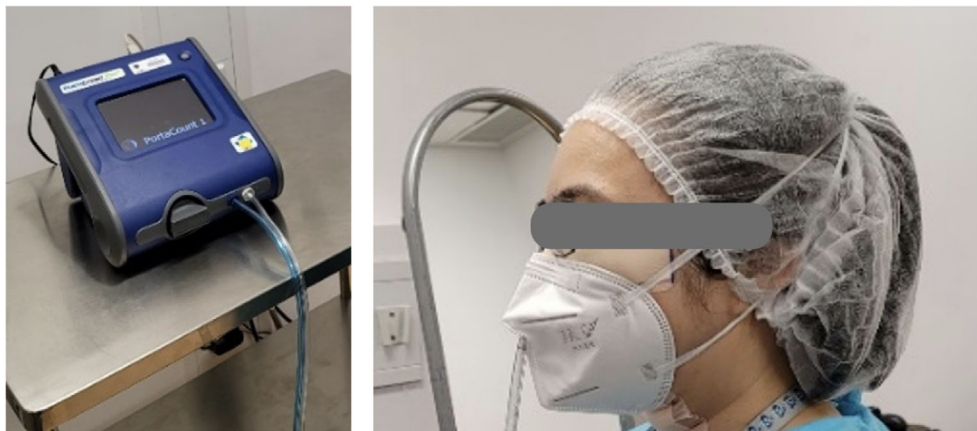
the nose, upper cheek, above the ears, and lower jaw. The dressings were gently removed between the fit tests without using adhesive removers. Each participant was asked to wear the respirator with the dressing materials applied underneath for 240 minutes in a safe environment. Subsequently, all participants underwent skin assessments again and provided feedback about their experiences with the prolonged use of the nanofiber bacterial surgical respirator together with the customised thin dressing.

This study used the quantitative method of a respirator fit test^{12,13} to measure how best the air seal could be maintained after the dressing materials were applied. The fit test was conducted in the nursing laboratories of a tertiary educational institute in Hong Kong. A team of trained nursing laboratory specialists performed a quantitative fit test of a nanofiber bacterial surgical respirator

on 24 HCPs. The fit-test process used the PortaCount Pro + Respirator Fit Tester 8038, which is an ambient aerosol condensation particle-counting device that offers quantitative measurements of the leakage from the airtight facial seal (Figure 5).¹⁴ The fit testing of tight-fitting respirators is presently a requirement worldwide,¹⁵ and the fit-testing machine is accepted as the fastest, easiest, and best fit-testing method for all tight-fitting respirators in several countries, including Hong Kong, and has been utilised by agencies such as the Health and Safety Executive in the United Kingdom,¹⁶ Canadian Standards Association in Canada,¹⁷ as well as the Occupational Safety and Health Administration¹³ and the American National Standards Institute in the United States.¹²

Prior to the fit test, each participant was required to wear the FFR for 5 minutes.¹⁸ During the test, a nursing laboratory specialist fitted a nanofiber bacterial surgical

FIGURE 5 Internationally certified quantitative fit test was conducted to ensure that all participants were wearing nanofiber bacterial surgical respirator with thin dressings in air-sealed conditions



respirator with a probe and connected it to the fit-testing machine via a small plastic tube. The probe adapter was installed using a sharp metal tool that pierced the nanofiber bacterial surgical respirator. A small plastic tube was connected from within the probe adaptor to the inside of the nanofiber bacterial surgical respirator. The placement of the probe adaptor is usually in the centre of the respirator, between the participant's nose and mouth.¹⁴ The fit-testing machine assessed the fit of the nanofiber bacterial surgical respirator worn by the participant while he or she performed a series of activities, such as normal breathing, deep breathing, turning the head from side to side, moving the head up and down, talking slowly and loudly, grimacing, bending at the waist, returning to an upright position, and breathing normally before the completion of the testing activities. Then, the fit-testing machine analyses the grading result to derive a fit factor for each of these activities as well as an overall combined grading result for all the activities.¹⁴

The fit-factor numerical grade of the fit test indicated the ratio of the number of particles calculated from the exterior and interior of the nanofiber bacterial surgical respirator and reflected the quantitative result of the fit test performed on the facepiece of a nanofiber bacterial surgical respirator and indicated, in the absence of air leakage, the effectiveness of the nanofiber bacterial surgical respirator against each participant's face. The tolerable fit factor for a nanofiber bacterial surgical respirator is more than 100.¹⁴

3 | RESULTS

The findings of the nanofiber bacterial surgical respirator fit test are presented in Table 1 (with the relevant descriptive statistics shown in Table 2). A fit factor of 114 or higher reflected an effective seal without leakage, and a grading result of 200 indicated maximum fit.¹⁴ Twelve

participants applied a light silicone foam dressing (Biatain) before donning the nanofiber bacterial surgical respirator, and 33% of these participants had a fit factor of 200. Another 12 participants applied a soft silicone perforated tape dressing (Siltape) before donning the nanofiber bacterial surgical respirator, and 58% of these participants had a fit factor of 200. Based on the mean fit factor and the corresponding 95% confidence interval in Table 2, all participants had an adequate, safe, and protective seal with the nanofiber bacterial surgical respirator after applying a light silicone foam dressing (Biatain) or soft silicone perforated tape dressing (Siltape).

All participants underwent skin assessments by the research team. All of the participants except one tolerated the dressings for prolonged use without any report of adverse skin reactions, such as hyperaemia, itching, pain, and discomfort, at the bridge of the nose, cheeks, and lower jaw. The dressing was tolerable for prolonged use. However, one participant complained of mild pain and hyperaemia with regard to acne on her cheeks.

Participants expressed various personal opinions after the prolonged use of the nanofiber bacterial surgical respirator with a thin dressing. The feedback from 24 HCPs highlighted main issues such as the perceived comfort, decreased skin erythema, and slippage of dressings after application.

My cheekbones were heavily marked without skin breakdown when I used the Nano mask (Nanofiber Bactericidal Surgical Respirator) the other day for more than 3 hours ... This was largely resolved with this dressing. It sealed better, [it was] so comfortable, as if I had not worn a Nano mask.

The bridge of my nose, my cheeks, and chin skin were not red or marked when I wore this dressing. [While wearing a nanofiber

TABLE 1 Nanofiber bactericidal surgical respirator fit-test findings

Dressing	Fit factor of participants (01 represents participant 1, 02 represents participant 2, etc.)																							
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Biatain light silicone foam dressing (n = 12)	200	185	181	195	200	123	114	200	200	104	149	159	—	—	—	—	—	—	—	—	—	—	—	—
Siltape soft silicone perforated tape dressing (n = 12)	—	—	—	—	—	—	—	—	—	—	—	148	200	195	200	200	159	188	200	200	151	200	200	200

TABLE 2 Descriptive statistics of the nanofiber bactericidal surgical respirator fit-test findings

Dressing	Mean fit factor (SD)	95% Confidence interval
Biatain light silicone foam dressing (n = 12)	167.5 (36.6)	146.8-188.2
Siltape soft silicone perforated tape dressing (n = 12)	186.8 (21.0)	174.9-198.6

bactericidal surgical respirator] my skin feels more comfortable than when wearing an N95 on a normal day.

I easily put the dressing on my face (both cheeks), the bridge of my nose, and lower chin in front of the mirror. I found that the dressings stuck to the mask very well after applying them to my cheeks. After wearing a Nano mask for a few hours, it was very easy to remove the dressing and it did not cause any pain.

4 | DISCUSSION

A limited number of articles have addressed the issue of respiratory protective equipment-induced MDRPI among HCPs.¹⁹ Several studies have reported concerns pertaining to the significance of adopting pre-emptive skincare practices to prevent MDRPI when FFRs were worn by HCPs for a prolonged period during their clinical practice.^{3,20} Darlenski and Tsankov²¹ argued that facial skin injury may make it easier for individuals to spread SARS-CoV-2. The prevalence of MDRPI among HCPs was highlighted in a study conducted in February 2020 with 4306 HCPs among 191 hospitals in China, in which 42.8% of HCPs had skin injuries related to the use of PPE.²² Importantly, these facial skin injuries induce complaints of discomfort, pain, and itching of the wearers of FFRs.²³ Further, the presence of small skin injuries, which may vary from superficial and bruising wounds to full-thickness wounds, may expose HCPs (the wearers) to a risk of infection as they continue to render health care in which airborne particles may carry the SARS-CoV-2.⁴ With tissue damage on facial locations, the skin is not able to act as a natural barrier to the immune system of well-being to fight against infectious diseases if there are skin tears.^{24,25} When the skin tears of HCPs make them carriers of infection, this adds to the risk of spread of transmissible diseases among the HCPs and their

patients.^{26,27} Thus, HCPs with open facial wounds should be advised to avoid bedside duties in the clinical setting because the respirator may be incorrectly donned on the face in an attempt to relieve pain at the open wound site, thereby creating an opportunity for HCPs to be susceptible to viral infections.²⁸ At the start of the UCTP, many participants were aware of the presence of skin injuries on their face, cheeks, ears, and lower jaw caused by prolonged use of respiratory protective equipment. By demonstrating that the dressing materials (applied under the nanofiber bacterial surgical respirators) did not decrease the respiratory protection, our study addressed the participants' needs of a protective dressing that may reduce the potential occurrence of pressure injury with the prolonged use of nanofiber bacterial surgical respirators.

According to NPIAP's position statement that highlighted the use of dressings to reduce MDRPI: '*There is currently no evidence that can ensure the safety from viral penetration when a dressing is placed under a respirator type mask. This could be particularly problematic in the case of dressings with a porous outer surface*'.¹⁰ Our study showed that, after applying a thin dressing on the bridge of the nose of the cheek bones, without stacking the dressings, the effectiveness of the air seal of a nanofiber bacterial surgical respirator was satisfactory as indicated by the fit factor results of the participants. As this study is not a randomised controlled trial, this may limit the generalizability of our findings. Therefore, further research is recommended to provide rigorous evidence in this regard. Nevertheless, our findings may move a step forward in assisting the process of developing feasible pre-emptive skincare practice guidelines to reduce MDRPI during the prolonged use of nanofiber bacterial surgical respirators. Finally, it should be noted that dressings applied under the respirators may also be contaminated during nursing procedures. Thus, HCPs should be educated to close their eyes and hold their breath during exhalation during dressing removal to prevent the transmission of SARS-CoV-2. The removed dressing materials should be properly discarded as per the infection control practice guidelines in the clinical setting for used nanofiber bacterial surgical respirators.

5 | CONCLUSION

This study examined whether the placement of two different types of thin dressings (light silicone foam dressing and soft silicone perforated tape dressing) used under nanofiber bacterial surgical respirators would interfere with the nanofiber bacterial surgical respirator's facial seal that is necessary to protect HCPs from exposure to

SARS-CoV-2 infection. Quantitative fit testing showed an adequate seal of the respirators with the use of both types of thin dressings that were available in the clinical settings. This study may lend support to the safe and potential use of thin dressings under the nanofiber bacterial surgical respirators in preventing MDRPI among health care providers.

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CONFLICT OF INTEREST

All authors (Y. C. YIP and K. H. YIP) declare no conflict of interest. All authors did not receive any funding from the manufacturers of the dressing materials in this study. All authors declare that they did not receive any funding from the respirator manufacturer. At the time of this study, all authors have no affiliations with any manufacturers of the materials used in this study. No manufacturer of the used materials in this study played any role in this study.

ETHICS STATEMENT

Ethical approval for the study was obtained from the Research and Ethics Committee of the Caritas Institute of Higher Education in Hong Kong (China) (reference no. HRE200122).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Ka-Huen Yip  <https://orcid.org/0000-0002-6988-214X>

Yuk-Chiu Yip  <https://orcid.org/0000-0002-2353-5433>

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