The outcomes and acceptance of pressurized metered-dose inhaler bronchodilators with venturi mask modified spacer in the outpatient emergency department during the COVID-19 pandemic

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Abstract
What is known and objective: Nebulizer use has been suspended in Malaysian public health facilities due to the potential to aggravate COVID-19 nosocomial transmission. Currently, our facility uses the pressurized metered-dose inhaler (pMDI) bronchodilator with Venturi mask modified spacer (VMMS) in patients visiting the Emergency Department (ED) for mild to moderate exacerbation of asthma and chronic obstructive pulmonary disease (COPD). We sought to assess the outcomes and acceptance of pMDI-VMMS in the outpatient ED of a tertiary hospital in Malaysia.

Methods: We analysed the total visits and discharge rates during periods of using the nebulizer and current pMDI-VMMS method. The acceptance of pMDI-VMMS by patients and assistant medical officers (AMOs) were assessed by questionnaire.

Results and discussion: We analysed 3184 ED visits and responses from 103 patients and 32 AMOs. The direct discharge rate was similar for both nebulizer (n = 2162, 92.5%) and pMDI-VMMS method (n = 768, 90.7%) (p-value = 0.120). Twenty-eight patients (27.2%) favoured the pMDI-VMMS over the nebulizer, whereas 36 patients (35.0%) had no preference for either method. Sixty-four patients (62.1%) felt that the current pMDI-VMMS method was better or at least as effective in relieving their symptoms as a nebulizer. The current method was favoured over the nebulizer by twenty-seven AMOs (84.4%). Twenty-eight (87.5%) AMOs suggested that the current method was more effective than the nebulizer.

What is new and conclusion: The bronchodilator delivered via pMDI-VMMS appeared to be comparable to nebulizer in treating mild to moderate asthma and COPD exacerbations in the outpatient ED. Most patients and AMOs accepted the use of pMDI-VMMS in the outpatient ED during the current COVID-19 pandemic. The Venturi mask modified spacer can be a cheap and effective alternative to the commercial spacer in a resource-limited situation.

KEYWORDS
aerosols generating procedures, COVID-19, emergency department, modified spacer, nebulizer
1 | WHAT IS KNOWN AND OBJECTIVE

The coronavirus disease 2019 (COVID-19) has impacted global healthcare practices. The prevention of SARS-CoV-2’s nosocomial transmission is vital as aerosol-generating processes (AGPs) can transmit SARS-CoV-2.1,2 AGP is defined as any medical procedure capable of inducing the development of aerosols of various sizes, including small particles (<5 μm).3 The high transmissibility and infectivity of SARS-CoV-2 is a concern as the virus viability in respirable-sized aerosols is up to 16 h within the laboratory environment.4

The use of nebulizer was listed as an AGP.1,5 Based on limited available data, the evidence of SARS-CoV-2 transmission via nebulization is inconclusive.6 A US study found three healthcare personnel who contracted COVID-19 had more exposure to the patients during their nebulizer treatments. However, the healthcare personnel might contract the COVID-19 from exposure to other AGPs.7 There were minimal data on the risk of virus transmission via nebulization from the previous severe acute respiratory syndrome (SARS) epidemic by SARS-CoV from 2002 to 2003. A Hong Kong study has theorized that salbutamol administration with nebulizer aggravated SARS transmission in the healthcare setting.8

Worldwide guidelines have proposed different recommendations on the use of nebulizers in the healthcare setting. Malaysian Thoracic Society9 and Benge and Barwise10 have recommended halting nebulizer use. Tashkin and Barjaktarevic11 suggested using negative pressure rooms, disposing of used equipment after each use and maintaining a minimum of 6-feet distance in patients requiring nebulizer treatment. However, guidelines from the United Kingdom (UK) recommended the continued use of nebulizers as the aerosol produced from nebulization is generated from medication and fluid from the nebulizer chamber. Therefore, it does not carry patient-derived viral particles.2,12,13 However, most COVID-19 cases are mild or asymptomatic, where patients themselves are not aware of being infected but can infect others.14 Besides, it is important to note that nebulizer treatment commonly induces or aggravates cough due to the lower temperature of the aerosolized liquid medications and massive dilution of sputum, which retains in the airway.15 Any bioaerosol generated by the patients, especially during coughing, can be dispersed via nebulization. Thus, delivering medications via nebulization to patients with undiagnosed COVID-19 can potentially aggravate the spread of the SARS-CoV-2 in the healthcare facilities.

The Emergency Department (ED) of Hospital Kuala Lumpur (HKL) stopped the use of nebulizers. The pMDI bronchodilator with a spacer was used after considering the risk of transmission by asymptomatic or pre-symptomatic patients, patients’ non-disclosure of their contacts or symptoms, sporadic cases and limited negative pressure environment for AGPs. A study has demonstrated comparable performance between the nebulizer and pMDI with the spacer in delivering short-acting beta2-agonists in acute asthma among paediatric patients.16 However, this finding is less certain in adults.17 Besides, most studies involving adult patients in emergency settings used only commercial spacers.18 In Malaysia, public healthcare facilities could not provide each patient with a commercial spacer considering the cost and stock availability in the Malaysian market due to the sudden surge in demand. Also, most commercial spacers were designed for single patient use and carry the risk of cross-infection if reused for another patient. Thus, the commercial spacer with a facemask was restricted for inpatient ED use. We initiated the use of pMDI bronchodilators with the Venturi mask modified spacer (pMDI-VMMS) in patients visiting the outpatient ED for mild to moderate asthma or COPD exacerbation. The VMMS is disposed of after every patient’s use, and the pMDI bronchodilator is given to the patient during discharge to avoid cross-infection.

An effective delivery method for bronchodilators is crucial to replace the use of the nebulizer temporarily. Currently, there is no study done to assess the outcomes of VMMS in delivering pMDI bronchodilators. From 30 March 2020 to 06 April 2020, a pilot survey involving 90 patients who attended ED showed encouraging 92.2% discharge rate results. Therefore, we aimed to assess the outcomes of pMDI-VMMS and the acceptance of this method by patients and assistant medical officers (AMOs) in the outpatient ED during the COVID-19 pandemic.

2 | METHODS

2.1 | Design, setting and population

This study is a single-centre prospective cross-sectional study conducted at outpatient ED HKL. HKL is the largest tertiary care hospital in Malaysia, with 247,492 ED attendances in 2019, of which approximately 14,400 (5.8%) ED attendances were visits due to mild and moderate asthma and COPD exacerbations. All patients with mild and moderate asthma and COPD exacerbations are managed by 2-3 assistant medical officers (AMOs) under the supervision of one medical officer (MO). AMOs are well-trained and proficient in conducting clinical examinations and assessments for acute exacerbation of asthma and COPD and provide the appropriate management for these patients. All AMOs were briefed on the in-house interim protocol on asthma and COPD management (Appendix 1) during the COVID-19 pandemic by an emergency clinical pharmacist and emergency physician during the implementation period. One 5 mg of nebulized salbutamol is equivalent to 5-10 puffs of MDI Salbutamol (100 mcg per dose) delivered with a spacer.9 One 0.5 mg of nebulized ipratropium is equivalent to 4 puffs of MDI Ipratropium (20 mcg per dose) delivered with a spacer.9

2.2 | Inclusion and exclusion criteria

The study’s inclusion criteria were as follows: adults above 18 years old who attended ED for mild and moderate asthma or COPD exacerbations, experience of receiving nebulizer treatment of short-acting bronchodilators before the COVID-19 pandemic and fit for discharge after receiving treatment. Patients who disagreed to participate,
discharged at their own risk against medical advice or did not understand Malay and English languages were excluded from the study. Patients must fulfil criteria as per ED HKL protocol before discharge, including resolution of symptoms, negative rhonchi, not tachypnoeic, \(\text{SpO}_2 \geq 95\%\) on room air, and having stable blood pressure and heart rate. In the AMOs group, only those with experience managing patients before and during the COVID-19 pandemic were recruited.

2.3 | Definition of asthma and COPD exacerbation

The severity of COPD exacerbation was based on cardinal symptoms, including increased dyspnoea, increased sputum volume and increased sputum purulence. In mild COPD exacerbation, only one of the three cardinal symptoms is present. Two out of three cardinal symptoms are required for the diagnosis of moderate COPD.\(^{18}\)

Mild and moderate asthma exacerbation includes patients who can talk in phrases or full sentences, not agitated, respiratory rate below 30 breaths per minute, heart rate below 120 beats per minute and oxygen saturation above 90% on pulse oximetry, without features of severe asthma exacerbation.\(^{19,20}\) The peak expiratory flow (PEF) measurement was stopped because of aerosol generation risk.

2.4 | Date collection

All patients with mild and moderate asthma or COPD exacerbations received the standard clinical evaluation and treatment by the AMOs using the current in-house interim protocol. Information was collected from the outpatient ED Registry, which included the date of visit, the number of visits, the number of patient identity documents (ID) or passports (for foreigners), and the visit outcome (discharged or up-triaged). Data for both nebulizer and pMDI-VMMS methods were retrieved for an equivalent period of 59 days to compare the outcomes between these two methods. During nebulizer treatment, the ED attendances were retrieved retrospectively as all nebulizer treatments were stopped during the COVID-19 pandemic.

A survey was conducted via questionnaires for both patients and AMOs to assess their acceptance of pMDI-VMMS. Patients were conveniently recruited during researchers’ dedicated research time from 16 May 2020 to 23 July 2020. Informed consent was obtained, and the patient information sheet was handed to patients who met the inclusion criteria, were fit for discharge and agreed to participate in the study. Recruited patients were given adequate time to complete the questionnaire for the survey. The researchers assisted patients who understood the Malay or English language but could not read due to some reasons such as visual impairment.

In the patients’ survey group, pertinent data including age, gender, race, underlying lung disease, clinical parameters pre-and post-treatment, and patient’s outcomes were obtained from out-patient ED clerking. Clinical parameters consisted of symptoms, auscultation findings, oxygen saturation, blood pressure, heart rate and respiratory rate. Clinical parameters were collected to ensure that enrolled patients fulfilled the discharge criteria. Patient outcomes consisted of patient discharged status, types of pMDI bronchodilator used and the total cycle of pMDI received.

The primary endpoints were the direct ED discharge rate and pMDI-VMMS’s acceptance. The pMDI-VMMS’s acceptance was assessed for both patients and AMOs. AMOs are the primary healthcare providers in handling patients with mild to moderate asthma or COPD exacerbations.

The questionnaires for both patients and AMOs groups were adapted from Khoo et al., who developed and used the questionnaire to assess patients’ and nurses’ acceptance and perspective of using pMDI with spacer during the SARS outbreak in Singapore.\(^{16}\) The author’s permission to use and to translate into the Malay language was obtained. The patients’ group questionnaire was forward and backward translated to Malay and English language by two Malay researchers independently for use in our multiracial local population. The Malay version questionnaire was tested on five Malay patients, cross-checked by another five Malay hospital staff members and approved by all researchers. The bilingual questionnaire consisted of 5 questions to explore patients’ experience of receiving nebulizer treatment and their feedback in respect of convenience, efficacy and potential preference aspects of using pMDI-VMMS by comparing it with their previous experience of nebulizer use.

The questionnaire for AMOs consisted of 6 questions aimed at exploring the feedback of AMOs on the efficacy, convenience, time consumption, problems experienced during the use of the pMDI-VMMS method and the future preference of the delivery system for bronchodilators after the COVID-19 pandemic is under control. Appendix 2 shows the questionnaires for the English edition used in this study.

2.5 | Data analysis and sample size

Convenience sampling method was used in patient recruitment. The needed sample size of 103 patients attending ED for mild and moderate asthma or COPD exacerbations was calculated by the proportion method using the online OpenEpi Version 3 Sample Size Calculator, accessed on 02 April 2020. All 32 AMOs who were currently managing patients with mild and moderate asthma or COPD exacerbations on a rotation basis were included in the questionnaire survey. Descriptive analysis was used for demographic data, clinical characteristics, treatment received and interview responses. Outcomes and relevant dichotomous data were analysed using the chi-square test or Fisher’s exact test where appropriate. All tests of significance with \(p\)-values of \(\leq 0.05\) were considered significant.
3  | RESULTS

3.1 | Subjects’ demographics

Data collected from 103 patients and 32 AMOs were analysed. The patients’ median age was 56 (39.0–67.0) years, and the majority of them were male (n = 67, 65.0%). Most patients who visited outpatient ED HKL were diagnosed with asthma (n = 61, 59.2%). All patients had experience of receiving nebulizer treatment in the public healthcare facilities. A single agent, pMDI bronchodilator, salbutamol, was used in most patients (n = 100, 97.1%) (Table 1).

### TABLE 1 Patients’ demographics, clinical characteristics and treatment received

| Characteristic                        | Descriptive Statistic, n (%) |
|---------------------------------------|------------------------------|
| Age, years                            | Median (IQR) 56.0 (39.0–67.0) |
|                                       | Range 18.0–84.0               |
| Gender                                | Male 67 (65.0)                |
|                                       | Female 36 (35.0)              |
| Race                                  | Malay 62 (60.2)               |
|                                       | Chinese 8 (7.8)               |
|                                       | Indian 31 (30.1)              |
|                                       | Others 2 (1.9)                |
| Underlying lung disease               | Asthma 61 (59.2)              |
|                                       | Chronic obstructive pulmonary disease 42 (40.8) |
| Duration of lung disease, years       | Median (IQR) 15.0 (6.0–29.0)  |
|                                       | Range 1.0–63.0                |
| On regular follow-up                  | Yes 71 (68.9)                 |
|                                       | No 32 (31.1)                  |
| History of receiving nebulization     | Yes 103 (100)                 |
|                                       | No 0 (0)                      |
| Type of pMDI bronchodilators received | Salbutamol 100 (97.1)         |
|                                       | Salbutamol plus ipratropium 3 (2.9) |
| Total cycles of pMDI bronchodilators received | Mean (SD) 2.0 (0.7) |
|                                       | Range 1.0–4.0                 |

Abbreviations: IQR, interquartile range; pMDI, pressurized metered-dose inhaler; SD, standard deviation.

3.2 | Outcomes of VMMS in delivering pMDI bronchodilators

The total number of visits to outpatient ED for mild and moderate asthma or COPD exacerbations was 2338 and 846 during the nebulizer and pMDI-VMMS method, respectively, for the same duration of 59 days. The direct discharge rate was similar for both nebulizer and pMDI-VMMS methods (p-value = 0.120) (Table 2).

3.3 | Patient interview responses

Table 3 summarizes the interview responses of the patients. Twenty-eight patients (27.2%) favoured pMDI-VMMS over nebulizer. Sixty-four patients (62.1%) thought that pMDI-VMMS was better or at least as effective in relieving their symptoms as nebulizer treatment. No association was found between patients’ underlying lung disease and their interview responses (Table 4).

3.4 | AMO interview responses

The AMOs’ interview responses were summarized in Table 5. Twenty-seven (84.4%) AMOs favoured pMDI-VMMS over nebulizer. Twenty-eight (87.5%) of AMOs feedback that pMDI-VMMS was more effective than a nebulizer in treating asthma and COPD exacerbation. Most AMOs thought the administration of pMDI-VMMS was easier and less time-consuming than the nebulizer.

### TABLE 2 Outcomes of pMDI-VMMS versus nebulizer at outpatient emergency department

|                          | Nebulizer | pMDI-VMMS | p-value $[X^2$ Statistics $(df =1)$] |
|--------------------------|-----------|-----------|-----------------------------------|
| Total visits, n          | 2338      | 846       |                                   |
| Average visit per day, n | 40        | 14        |                                   |
| Number of patients       | 2162 (92.5) | 768 (90.7) | 0.120 $[2.42 (1)]$               |

### TABLE 3 Patient interview responses (n = 103)

|                             | Nebulizer | pMDI-VMMS | No preference/same |
|-----------------------------|-----------|-----------|--------------------|
| Overall preference, n (%)   | 39 (37.9) | 28 (27.1) | 36 (35.0)           |
| Which is better in relieving symptoms, n (%) | 39 (37.9) | 36 (35.0) | 28 (27.1)           |
| Which is easier to use, n (%) | 28 (27.2) | 6 (5.8)   | 69 (67.0)           |
Venturi mask modified spacer was used as the alternative to the commercial spacer in our setting. To our knowledge, this is the first study reporting the outcomes of pMDI-VMMS during the COVID-19 pandemic. Research on using a modified or non-commercial spacer demonstrated that the 6-inch tube (1-inch inside diameter) was as effective as commercial spacers in delivering fluticasone dipropionate metered-dose inhaler at a straight position. However, several other factors were considered during the search for an alternative to the commercial spacer. These included reduced inspiratory effort and coordination during an exacerbation and patients' preference to use a face mask. The face mask and 6-inch tube from the Venturi mask set were selected as the alternative to deliver pMDI bronchodilators. The Venturi mask set is readily available in the hospital setting and costs less than 3.60 Ringgit Malaysia (0.84 US dollars).

There was no significant difference in the rate of direct discharges between the pMDI-VMMS versus nebulizer among patients attending outpatient ED for mild and moderate asthma or COPD exacerbations. Thus, based on our study outcomes, pMDI-VMMS is as effective as the nebulizer. Our direct discharge rates for both bronchodilators' delivery methods were slightly higher than stated in the literature. In adult patients who visited the community and emergency settings for acute asthma exacerbation, the discharge rates for the nebulizer and pMDI with spacer methods were 89.1% and 89.7%, respectively. However, patients with severe exacerbations of asthma or COPD, which were not included in our research, may be included in other studies. In our setting, less than 10% of our patients were up-triaged to inpatients ED higher acuity zones for further management after the initial four cycles of pMDI bronchodilators failed. However, not all up-triaged patients were warded.

Despite the abrupt switch of the bronchodilator delivery system at outpatient ED, the use of pMDI-VMMS was accepted and preferred by the majority of the patients. However, a substantial number of patients (n = 39, 37.9%) still preferred bronchodilator administration via nebulizer, although the pMDI-VMMS successfully reversed their asthma or COPD exacerbation. These patients indicated that they felt better and more comfortable with nebulizer therapy, as there was oxygen supply.

The use of pMDI-VMMS was accepted and favoured by most AMOs. As the preparation steps are much more manageable, pMDI-VMMS is less time-consuming than giving nebulizer treatment (Appendix 1). Also, the length of treatment for pMDI-VMMS was shorter compared to the nebulizer. One cycle (6–8 pMDI salbutamol puffs, 100 mcg/puff) of pMDI-VMMS requires 5 min, whereas one nebulizer treatment cycle requires 10–15 min. Our results were entirely contradictory to a Singaporean study during the 2003 SARS epidemic, where 96% of nurses stationed in respiratory wards chose nebulizer care over pMDI plus a commercial spacer. In the study, most nurses thought the use of nebulizer was more effective in treating asthma and COPD exacerbation. The author attributed these findings to nurses' misconceptions on the efficacy and patients' ability to use pMDI with commercial spacer.

During this COVID-19 pandemic where the use of nebulizer is discouraged, our study offered insight into the efficacy of pMDI bronchodilators delivered via VMMS to treat mild to moderate asthma and COPD exacerbation in the outpatient ED. Also, the acceptance of this method by both the patients and AMOs indicates that VMMS can be an efficient alternative to a commercial spacer in delivering pMDI bronchodilators. This finding is particularly important when an outbreak or pandemic of airborne infection requires

### Table 4: Association between diagnosis of underlying lung disease and patient interview responses (n = 103)

| Variable | n | BA | COPD | p-value [X² Statistics (df = 1)] |
|----------|---|----|------|----------------------------------|
| Overall preference | | | | |
| Nebulizer | 39 | 25 | 14 | 0.432 [0.62 (1)] |
| pMDI-VMMS or no preference | 64 | 36 | 28 | |
| Which is better in relieving symptoms | | | | |
| Nebulizer | 39 | 25 | 14 | 0.432 [0.62 (1)] |
| pMDI-VMMS or no preference | 64 | 36 | 28 | |
| Which is easier to use | | | | |
| Nebulizer | 28 | 20 | 8 | 0.124 [2.37 (1)] |
| pMDI-VMMS or no preference | 75 | 41 | 34 | |

Abbreviations: df, degree of freedom; pMDI-VMMS, pressurized metered-dose inhaler bronchodilators with Venturi mask modified spacer; X², chi-square test.

### Table 5: Interview response of assistant medical officers

| Variable | Nebulizer | pMDI plus VMMS | No preference/same |
|----------|-----------|----------------|-------------------|
| Overall preference, n (%) | 2 (6.3) | 27 (84.4) | 3 (9.4) |
| Which is more effective, n (%) | 2 (6.3) | 28 (87.5) | 2 (6.3) |
| Which is more convenient, n (%) | 3 (9.4) | 25 (78.1) | 4 (12.5) |
| Which is less time-consuming, n (%) | 0 (0.0) | 30 (93.8) | 2 (6.2) |
| Which method to use when COVID-19 in under control | 3 (9.4) | 26 (81.3) | 3 (9.4) |

Abbreviations: COVID-19, coronavirus disease 2019; pMDI, pressurized metered-dose inhaler; VMMS, venturi mask as modified spacer.

### DISCUSSION

4 - DISCUSSION
another bronchodilator delivery method other than nebulizer, there are limitations in healthcare resources, or limited availability of commercial spacers due to sudden surge in demand.

Nevertheless, we note some limitations of this research. The unique setting of the current COVID-19 pandemic does not allow for a head-to-head trial of both bronchodilators’ delivery methods, which will provide a more reliable comparison of the two methods’ efficacy. Secondly, peak expiratory flow rate (PEFR), the objective measurement of lung function, was not carried out due to the potential risk of cross-contamination and bioaerosol production by undiagnosed pre-symptomatic or asymptomatic COVID-19 patients. We are aware that the acceptance and favouritism over a method do not necessarily translate into better treatment outcomes. Lastly, this study involved only patients fit for discharge. Patients (less than 10%) that have been up- triaged to higher acuity inpatients ED zones for further management may have a different opinion.

5 | WHAT IS NEW AND CONCLUSION

The bronchodilator delivered via pMDI-VMMS was comparable to a nebulizer in treating mild to moderate asthma and COPD exacerbations in the outpatient ED. Most patients and AMOs accepted the use of pMDI-VMMS in the outpatient ED during the current COVID-19 pandemic. In healthcare facilities treating mild to moderate asthma and COPD exacerbations, pMDI-VMMS can be an alternative to the nebulizer to minimize aerosol-generating procedures. The Venturi mask modified spacer can be a cheap and effective alternative to the commercial spacer in resource-limited situation during COVID-19 pandemic. However, further study on the pMDI drug delivery via VMMS and lung function is needed to ascertain this delivery method’s clinical efficacy.

ACKNOWLEDGEMENT

We would like to thank the Director-General of Health Malaysia for his permission to publish this article. We also like to thank Dr Mahathar Abd Wahab, Head of Emergency Department, and Dr Rahela Ambaras Khan, Head of Clinical Pharmacists, Hospital Kuala Lumpur, for critically reviewing this manuscript.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

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How to cite this article: Koh HP, Shamsudin NS, Tan MM, Mohd Pauzi Z. The outcomes and acceptance of pressurized metered-dose inhaler bronchodilators with venturi mask modified spacer in the outpatient emergency department during the COVID-19 pandemic. *J Clin Pharm Ther*. 2021;46:1129-1138. https://doi.org/10.1111/jcpt.13410
APPENDIX 1
The Interim Protocol on the Management of Bronchial Asthma and COPD Exacerbation during the COVID-19 Pandemic, Emergency & Trauma Department, Hospital Kuala Lumpur (updated 27th March 2020).
Procedures to Use Venturi Mask as Modified Spacer to deliver pMDI Bronchodilators

Step 1:
Take out the Venturi Mask (VM) and 6-inch Flexible tube

Step 2:
Attach flexible tube to the VM port

Step 3:
- Cover around 80% area of both VM exhalation ports with tape.
- Do not completely seal the exhalation port in order to allow some air exchange

Step 4: Prepare the MDI Priming:
- Shake the MDI for 3 – 5 times (1 shake = up and down),
- Open the cap
- Spray the inhaler.
- Repeat for 2 – 3 times.

Step 5:
Connect the MDI to VM by insert the mouthpiece into the flexible tube

Step 6: Administration
A. Ensure the VM is fitted properly to the face to prevent leakage
B. Hold the MDI upright as shown in the picture above.
C. To load 1 puff at a time every 30 seconds.
D. Press the MDI to load 1 puff follow with at least 5 tidal breaths by the patient
E. Repeat step D until completed the required dose.
F. Allow patient to rest for 10 minutes.
G. Reassess patient
### Survey Questionnaire—Patients

| Question                                                                 | Options                                                                 |
|------------------------------------------------------------------------|-------------------------------------------------------------------------|
| 1. Are you on regular follow-up in the hospital/clinic for your lung   | Yes/No                                                                  |
| disease?                                                               |                                                                         |
| 2. Do you have any experience of receiving nebuliser in the emergency  | Yes/No                                                                  |
| department to relieve the attack of your lung disease?                 |                                                                         |
| 3. In your opinion, which method is better in relieving your symptoms? | pMDI with venturi mask/nebuliser/same                                   |
| 4. In your opinion, which method is easier to use?                     | pMDI with venturi mask/nebuliser/same                                   |
| 5. The next time you have an attack, which method would you prefer to  | pMDI with venturi mask/nebuliser/no preference                          |
| receive in the emergency department?                                   |                                                                         |

### Survey Questionnaire—Assistant Medical Officers

| Question                                                                 | Options                                                                 |
|------------------------------------------------------------------------|-------------------------------------------------------------------------|
| 1. Based on your experience, which method of administering bronchodilators is more effective in treating the patient with asthma/COPD exacerbation presented to Asthma Bay? | pMDI with venturi mask/nebuliser/same/unsure                           |
| 2. Assuming that both methods of administration are of equivalent efficacy, which method do you prefer? | pMDI with venturi mask/nebuliser/no preference                          |
| 3. Which method is more convenient?                                     | pMDI with venturi mask/nebuliser/same/unsure                           |
| 4. Which method is less time consuming?                                 | pMDI with venturi mask/nebuliser/no preference                          |
| 5. Did you face any difficulty during the administration of MDI + Venturi Mask as spacer? | No/Yes. Please specify                                                  |
| 6. When the COVID−19 pandemic is under control, do you think the Asthma Bay Emergency Department should | Continue pMDI with venturi mask/switch back to nebuliser/no preference |
| continue pMDI with venturi mask/switch back to nebuliser/no preference |

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**Survey Questionnaire—Patients**

1. Are you on regular follow-up in the hospital/clinic for your lung disease? Yes/No
2. Do you have any experience of receiving nebuliser in the emergency department to relieve the attack of your lung disease? Yes/No
3. In your opinion, which method is better in relieving your symptoms? pMDI with venturi mask/nebuliser/same
4. In your opinion, which method is easier to use? pMDI with venturi mask/nebuliser/same
5. The next time you have an attack, which method would you prefer to receive in the emergency department? pMDI with venturi mask/nebuliser/no preference

**Survey Questionnaire—Assistant Medical Officers**

1. Based on your experience, which method of administering bronchodilators is more effective in treating the patient with asthma/COPD exacerbation presented to Asthma Bay? pMDI with venturi mask/nebuliser/same/unsure
2. Assuming that both methods of administration are of equivalent efficacy, which method do you prefer? pMDI with venturi mask/nebuliser/no preference
3. Which method is more convenient? pMDI with venturi mask/nebuliser/same/unsure
4. Which method is less time consuming? pMDI with venturi mask/nebuliser/no preference
5. Did you face any difficulty during the administration of MDI + Venturi Mask as spacer? No/Yes. Please specify
6. When the COVID−19 pandemic is under control, do you think the Asthma Bay Emergency Department should continue pMDI with venturi mask/switch back to nebuliser/no preference