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Evidence-based recommendations for preventing nosocomial transmission during respiratory care for COVID-19 patients

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Rush University

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Outline

- Infection rate among clinicians
- High-risk procedures and interventions
  - Cough and mask
  - Oxygen therapy
    - Nasal cannula
    - Oxygen mask: simple mask, venturi mask, nonbreather mask
    - High flow nasal cannula
  - Noninvasive ventilation
    - Settings
    - Masks
  - Manual ventilation
  - Intubation
  - Suctioning
  - Nebulization
  - Bronchoscopy examination
  - Personal protection equipment (PPE)

Medical staff infection rate in China

- 3,300 clinicians in total 80,000 cases were infected by COVID-19

Zhonghua Jie He He Hu Xi Za Zhi. 2020 Mar 12;43(3):209-214

Clinical characteristics of 30 medical workers infected with new coronavirus pneumonia

Liu Min[1],He Peng[2], Liu Huiguo[4],Wang Xiaojiang[1],Li Fajiu[1],Chen Shi[1],Lin Jie[3],Chen Bo[3],Liu Jianhua[3],Li Chenghong[1]. [1]Department of Respiratory and Critical Care Medicine,the Affiliated Hospital of Jianghan University,Wuhan430015,China;[2]Department of geriatrics,the Affiliated Hospital of Jianghan University,Wuhan430015,China;[3]Department of generalization,the Affiliated Hospital of Jianghan University,Wuhan430015,China;[4]Department of Respiratory and Critical Care Medicine,Tongji Hospital Affiliated to Tongji Medical College of HUST,Wuhan430030,China

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[Abstract] Objective To investigate the clinical characteristics of medical staff with novel coronavirus pneumonia(NCP). **Methods** 30 patients infected with novel coronavirus referred to jianghan university hospital between January 11, 2020 and January 3, 2020 were studied. The data reviewed included those of clinical manifestations，laboratory investigation and Radiographic features. **Results**The patients consisted of 10 men and 20 women, including 22 doctors and 8 nurses,aged 21~59 years(mean 35±8 years).They were divided to 26 common type and 4 severe cases, all of whom had close(within 1m) contact with patients infected of novel coronavirus pneumonia. The average contact times were 12（7,16） and the average cumulative contact time was 2（1.5,2.7）h.Clinical symptoms of these patients were fever in 23 patients（76.67%）, headache in 16 petients

Pre-PPE period: surgical mask

Post-PPE period: N95, single use gown, gloves, hat. Face shield or goggles if performing intubation

组别	例数	临床分型	
		普通型	重型
		Mild (26)	Critical (4)
防护前	19	15	4
		(78.95)	(21.05)
防护后	11	11	0
		(100)	(0)
合计	30	26	4
		(86.67)	(13.33)

表3 普通型与重症患者接触史及临床特征的比较（$\bar{x}\pm s$）

临床资料	Mild (26)	Critical (4)	*t* 值	*P* 值
体重指数（kg/m^2）	22.0±1.3	27.0±2.5	-8.382	<0.001
接触次数（次）	7.9±2.6	24.1± 6.8	-6.207	<0.001
累计接触时间（h）	1.9±1.0	3.0±0.7	-7.162	<0.001
平均热程（d）	3.4±2.4	8.6±5.8	-3.373	<0.001

Contact frequency

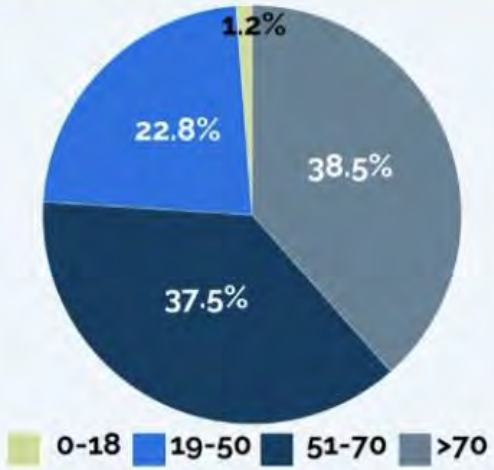
Contact time

Integrated surveillance of COVID-19 in Italy

13.882 cases of COVID-19*

1.116 health-care workers$

803 associated deaths



Age (years)	Deaths [n (%)]	CFR
0-9	0 (0%)	0%
10-19	0 (0%)	0%
20-29	0 (0%)	0%
30-39	1 (0.1%)	0.1%
40-49	1 (0.1%)	0.1%
50-59	14 (1.7%)	0.6%
60-69	65 (8.1%)	2.7%
70-79	274 (34.2%)	9.6%
80-89	355 (44.3%)	16.6%
>90	75 (9.3%)	19%
Not reported	18 (2.2%)	3.2%
Total	803 (100%)	5.8%

https://urldefense.com/v3/__https://youtu.be/TKS1pahoPRU__;!!OlavHw!oZDOFLppvOhOshLYCoGmYrSVBl2JFqdYFP5GCse33NFIaDMCFwwGjvdv4zUnWMQ$

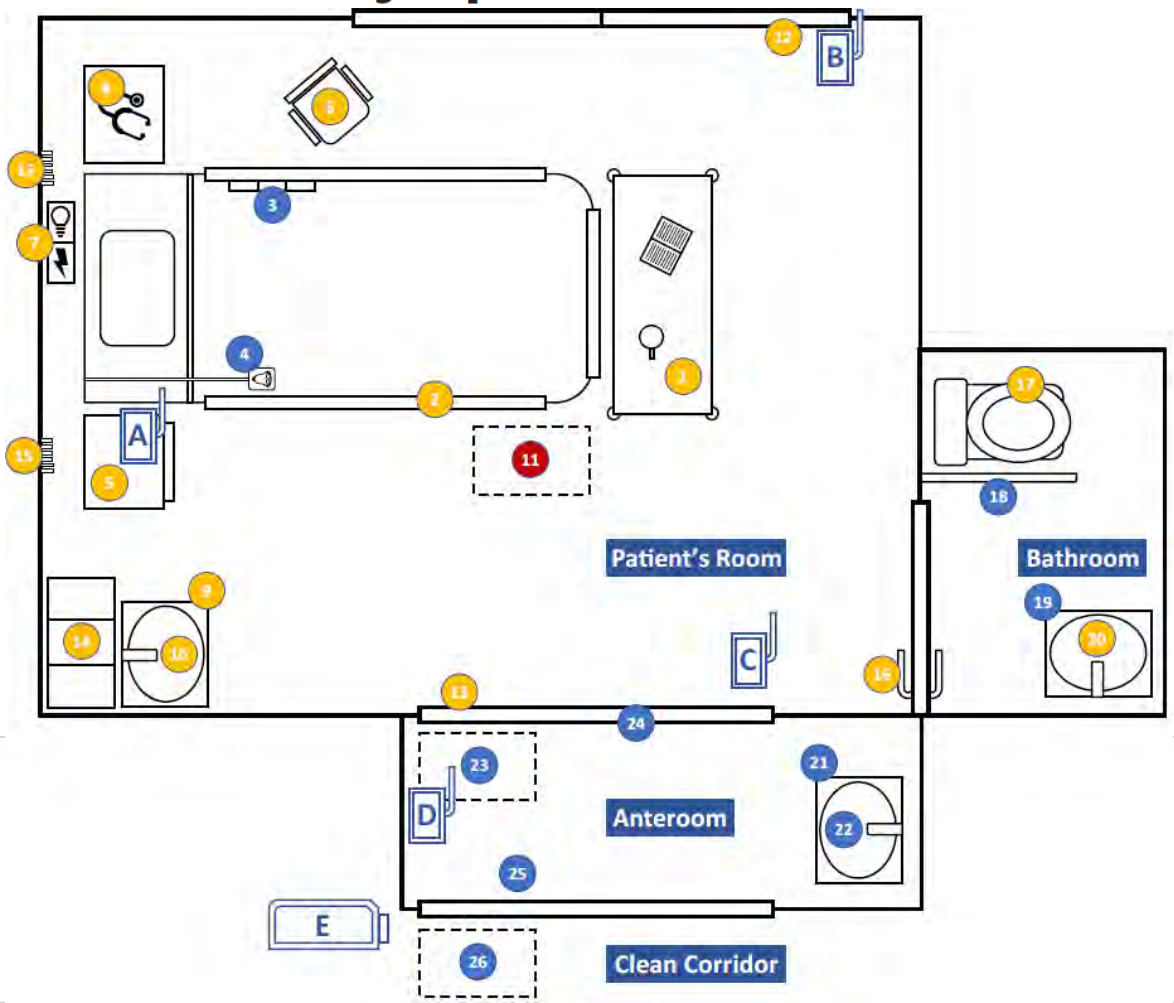
Clinicians' infection rate during SARS

Table 1 Numbers of Probable Cases of SARS, Deaths, and Healthcare Workers Infected in Selected Countries and Globally

	Cumulative No. of Cases	Deaths No. (%)	Workers Infected No. (%)
Canada	251	41 (17)	108 (43)
China	5,327	349 (7)	1,002 (19)
Hong Kong	1,755	299 (17)	386 (22)
Taiwan	346	37 (11)	68 (20)
Philippines	14	2	4 (29)
Singapore	238	33	97 (41)
Thailand	9	2	1 (11)
Vietnam	63	5	36 (57)
Global	8,098	774	1,707 (21)

INT J OCCUP ENVIRON HEALTH 2004;10:421–427

Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient



JAMA. 2020 Mar 4. doi: 10.1001/jama.2020.3227

- Red: strong positive results (low Ct value, ≤32).
- Yellow: weak positive results (high Ct value, >32).
- Blue: no positive results.
- Air sampling: negative result
- Letter (A,B,C,D,E): air sample

High-risk procedures

Transmission of Severe Acute Respiratory Syndrome during Intubation and Mechanical Ventilation

Robert A. Fowler, Cameron B. Guest, Stephen E. Lapinsky, William J. Sibbald, Marie Louie, Patrick Tang, Andrew E. Simor, and Thomas E. Stewart

Interdepartmental Division of Critical Care Medicine, University of Toronto, Sunnybrook and Women's College Health Sciences Centre; Intensive Care Unit, Mount Sinai Hospital; and Department of Microbiology, Division of Infectious Diseases, University of Toronto, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada

Nosocomial transmission of severe acute respiratory syndrome from critically ill patients to healthcare workers has been a prominent and worrisome feature of existing outbreaks. We have observed a greater risk of developing severe acute respiratory syndrome for physicians and nurses performing endotracheal intubation (relative risk [RR], 13.29; 95% confidence interval [CI], 2.99 to 59.04; p = 0.003). Nurses caring for patients receiving noninvasive positive-pressure ventilation may be at an increased risk (RR, 2.33; 95% CI, 0.25 to 21.76; p = 0.5), whereas nurses caring for patients receiving high-frequency oscillatory ventilation do not appear at an increased risk (RR, 0.74; 95% CI, 0.11 to 4.92; p = 0.6) compared with their respective reference cohorts. Specific infection control recommendations concerning the care of critically ill patients may help limit further nosocomial transmission.

Am J Respir Crit Care Med 2004: 1198–1202

OPEN ACCESS Freely available online

PLOS ONE

Influenza Aerosols in UK Hospitals during the H1N1 (2009) Pandemic – The Risk of Aerosol Generation during Medical Procedures

Plus one 2013; 8: e56278

Katy-Anne Thompson[1]*, John V. Pappachan[2], Allan M. Bennett[1], Himanshu Mittal[3], Susan Macken[1], Brian K. Dove[4], Jonathan S. Nguyen-Van-Tam[5], Vicky R. Copley[6], Sarah O'Brien[7], Peter Hoffman[8], Simon Parks[1], Andrew Bentley[9], Barbara Isalska[10], Gail Thomson[11], on behalf of the EASE Study Consortium[¶]

Procedure	Number of sampling occasions (number of patients)	% RNA collected >7.3 μm	% RNA collected 4–7.3 μm	% RNA collected 0.86–4 μm	Median copy no./l (inter-quartile range) for samples with at least one stage with detectable RNA
Baseline	76 (39)	78.7	11.1	10.2	7,913 (2,436–11,613)
Bronchoscopy	3 (3)	24.9	45.2	29.9	148,805 (12,735–284,875)
Respiratory & Airway Suction	14 (11)	22.4	29.7	47.9	1,852 (1,543–2,7521)
Intubation	5 (4)	0.0	100.0	0.0	2,838 (2,838–2,838)

viruses

MDPI

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Review

Nosocomial Transmission of Emerging Viruses via Aerosol-Generating Medical Procedures

Viruses **2019**, 11: 940

Seth D. Judson [1,2] and Vincent J. Munster [2,*]

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* Correspondence: munstervj@niaid.nih.gov; Tel.: +1-406-375-7489

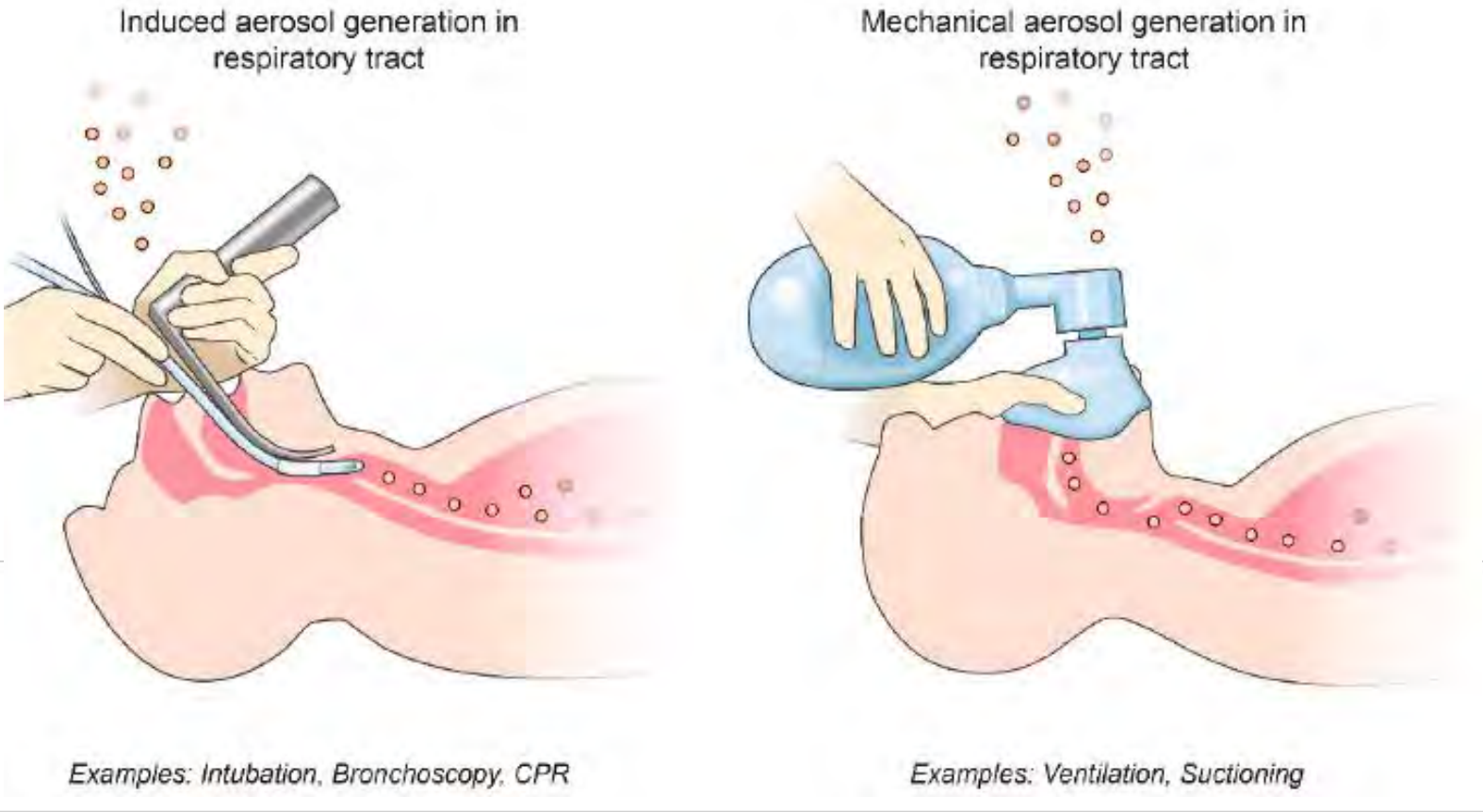

Table 1. Potential aerosol-generating medical procedures involved in nosocomial virus transmission.

AGMP	How/Where Aerosols May Be Generated
Bronchoscopy *	Induced cough, respiratory tract
Cardiopulmonary resuscitation *	Induced cough, respiratory tract
Noninvasive ventilation * (BiPAP, CPAP, HFOV)	Possible mechanical dispersal of aerosols, respiratory tract
Tracheal intubation *	Induced cough, respiratory tract
Manual ventilation *	Possible mechanical dispersal of aerosols, respiratory tract
Surgery	Cutting bone and tendon, and irrigation aerosolize blood
Sputum induction	Induced cough, respiratory tract
Nebulizer treatment	Possible mechanical dispersal of aerosols, respiratory tract
Suctioning	Possible mechanical dispersal of aerosols, respiratory tract
Laser plume	Mechanical dispersal of aerosols

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Table 1: Risk of SARS Transmission to HCWs Exposed and Not Exposed to Aerosol-Generating Procedures, and Aerosol-Generating Procedures as Risk Factors for SARS Transmission

Aerosol-Generating Procedures	OR (95% CI)
Tracheal intubation (4 cohort studies)	3.0 (1.4, 6.7)[25]
	22.8 (3.9, 131.1)[26]
	13.8 (1.2, 161.7)[27]
	5.5 (0.6, 49.5)[29]
Pooled estimate (I^2 = 39.6%)	6.6 (2.3, 18.9)
Tracheal intubation (4 case-control studies)	0.7 (0.1, 3.9)[23]
	9.2 (4.2, 20.2)[21]
	8.0 (3.9, 16.6)[20]
	9.3 (2.9, 30.2)[24]
Pooled estimate (I^2 = 61.4%)	6.6 (4.1, 10.6)
Suction before intubation (2 cohort studies)	13.8 (1.2, 161.7)[27]
	1.7 (0.7, 4.2)[25]
Pooled estimate (I^2 = 59.2%)	3.5 (0.5, 24.6)
Suction after intubation (2 cohort studies)	0.6 (0.1, 3.0)[27]
	1.8 (0.8, 4.0)[25]
Pooled estimate (I^2 = 28.8%)	1.3 (0.5, 3.4)
Nebulizer treatment (3 cohort studies)	6.6 (0.9, 50.5)[27]
	0.1 (0.0*, 1.0)[28]
	1.2 (0.1, 20.7)[25]
Pooled estimate (I^2 = 73.1%)	0.9 (0.1, 13.6)
Manipulation of oxygen mask (2 cohort studies)	17.0 (1.8, 165.0)[27]
	2.2 (0.9, 4.9)[25]
Pooled estimate (I^2 = 64.8%)	4.6 (0.6, 32.5)
Bronchoscopy (2 cohort studies)	3.3 (0.2, 59.6)[27]
	1.1 (0.1, 18.5)[25]
Pooled estimate (I^2 = 0%)	1.9 (0.2, 14.2)
Non-invasive ventilation (2 cohort studies)	2.6 (0.2, 34.5)[26]
	3.2 (1.4, 7.2)[25]
Pooled estimate (I^2 = 0%)	3.1 (1.4, 6.8)

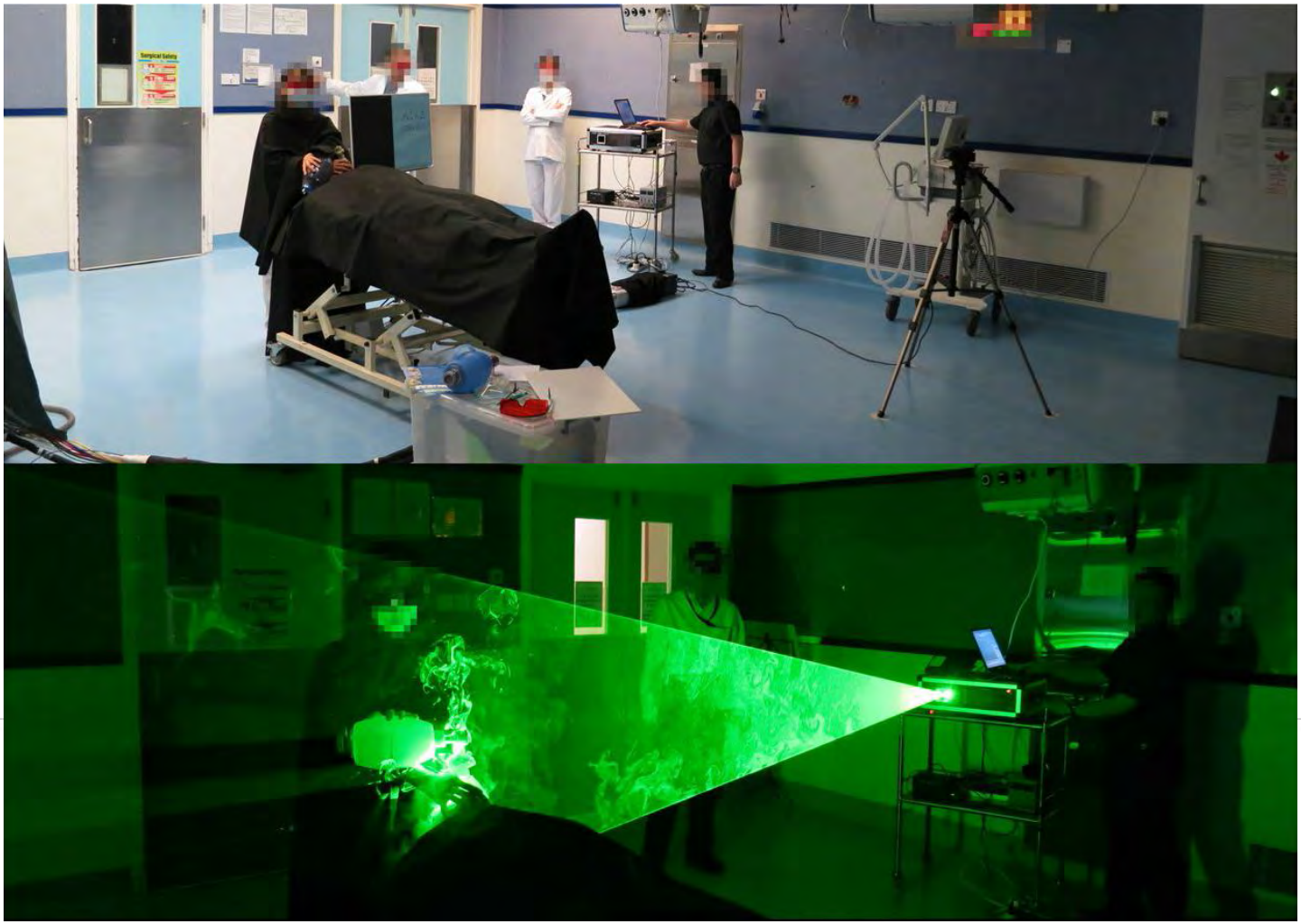
High-risk procedures and interventions

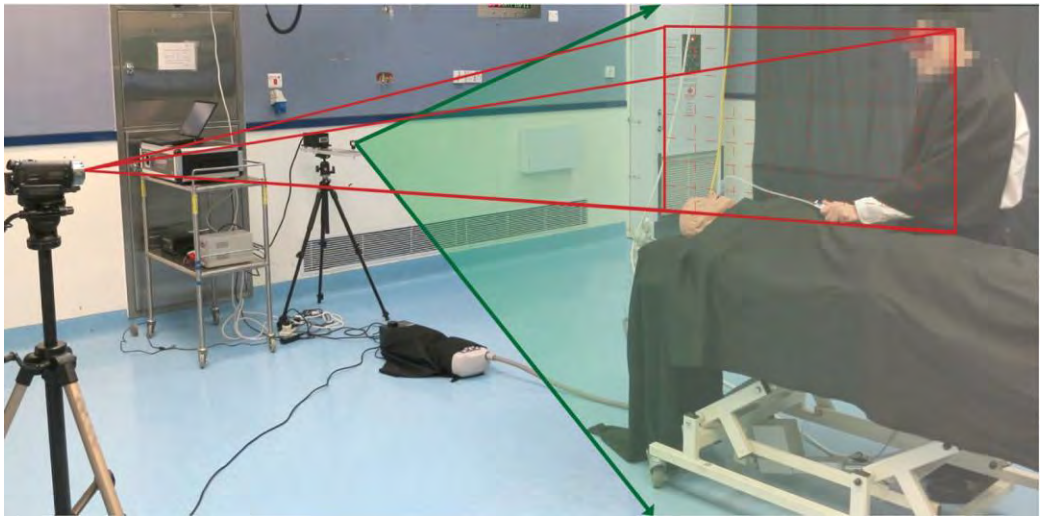
- Cough and mask
- Oxygen therapy
  - Nasal cannula
  - Oxygen mask: simple mask, venturi mask, nonbreather mask
  - High flow nasal cannula
- Nebulization
- Noninvasive ventilation
  - Settings
  - Masks
- Manual ventilation
- Intubation
- Suctioning
- Bronchoscopy examination
- Personal protection equipment (PPE)

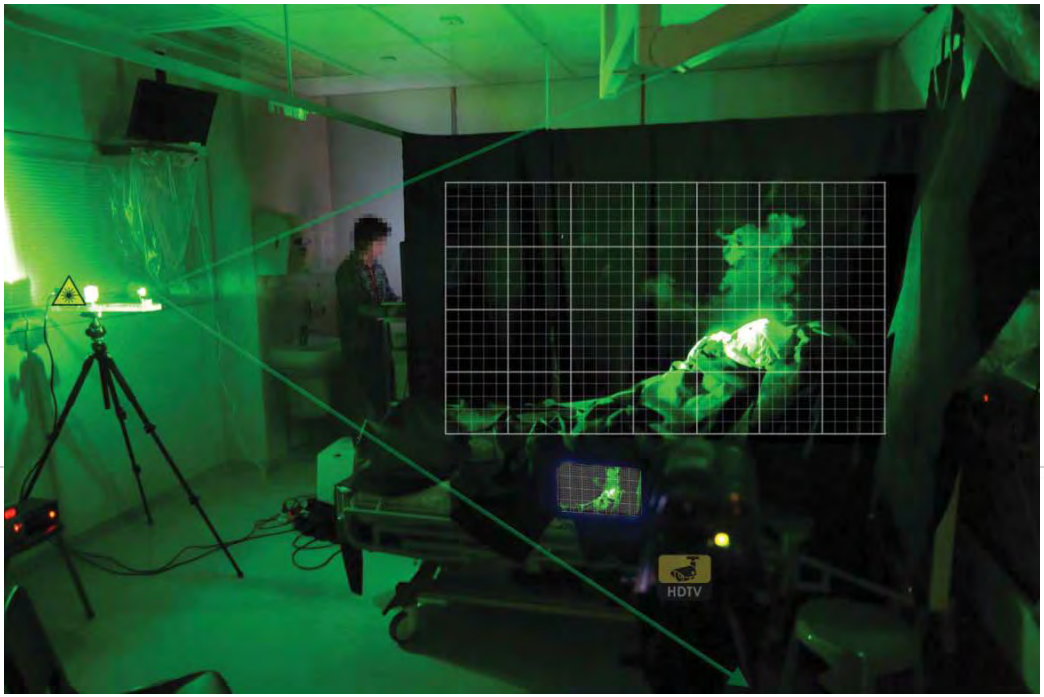
Methods utilized in studies investigated aerosol dispersion/transmission

- In vitro studies
  - Exhaled gas dispersion distance
  - Aerosol/droplet particle mass/count concentration
- In vivo studies
  - Aerosol/droplet particle mass/count concentration
  - RT-PCR test for air sample

Exhaled gas dispersion distance measurement



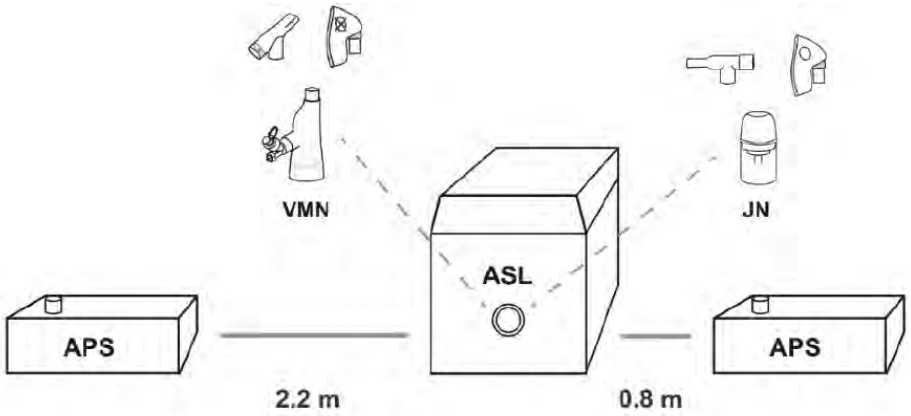




Flow visualization:

- Smoke particles of <1 μm in diameter, produced by a M-6000 smoke generator (N19, DS Electronics, Sydney, Australia) was used to highlight exhaled airflow
- A 6 FG catheter was inserted into the right main bronchus of the HPS to deliver smoke particles.
- After mixing with alveolar gas, smoke particles were exhaled through the normal airway passage.
- Leakage jet plume were then illuminated by a green (532 nm wavelength) laser light-sheet using a continuous pulse, diode-pumped solid state laser generator (OEM UGH-800 mW, Lambdapro Technologies, China)

Aerosol/droplet particle mass/count concentration



Pharmaceutics **2019**, 11, 75

Air sampling

- RT-PCR test
- A method used to find out what airborne contaminants are present in your environment.
  - Air is collected by using various methods and then, it is tested for the presence and concentration of hazardous substances and microorganisms

Natures of aerosol

- Bioaerosol
  - Generated by patients during coughing, breathing, or talking, laughing
- Medical aerosol
  - Generated by aerosol device, including MDI, DPI, SVN, VMN, USN, etc

When medical aerosol is contaminated?

- During medication/ device preparation
  - repeated use of SVN
- During inhalation /nebulization
  - Patient's secretion drops into SVN reservoir
- When inhaled aerosol is exhaled and carried with pathogen
  - Not sure

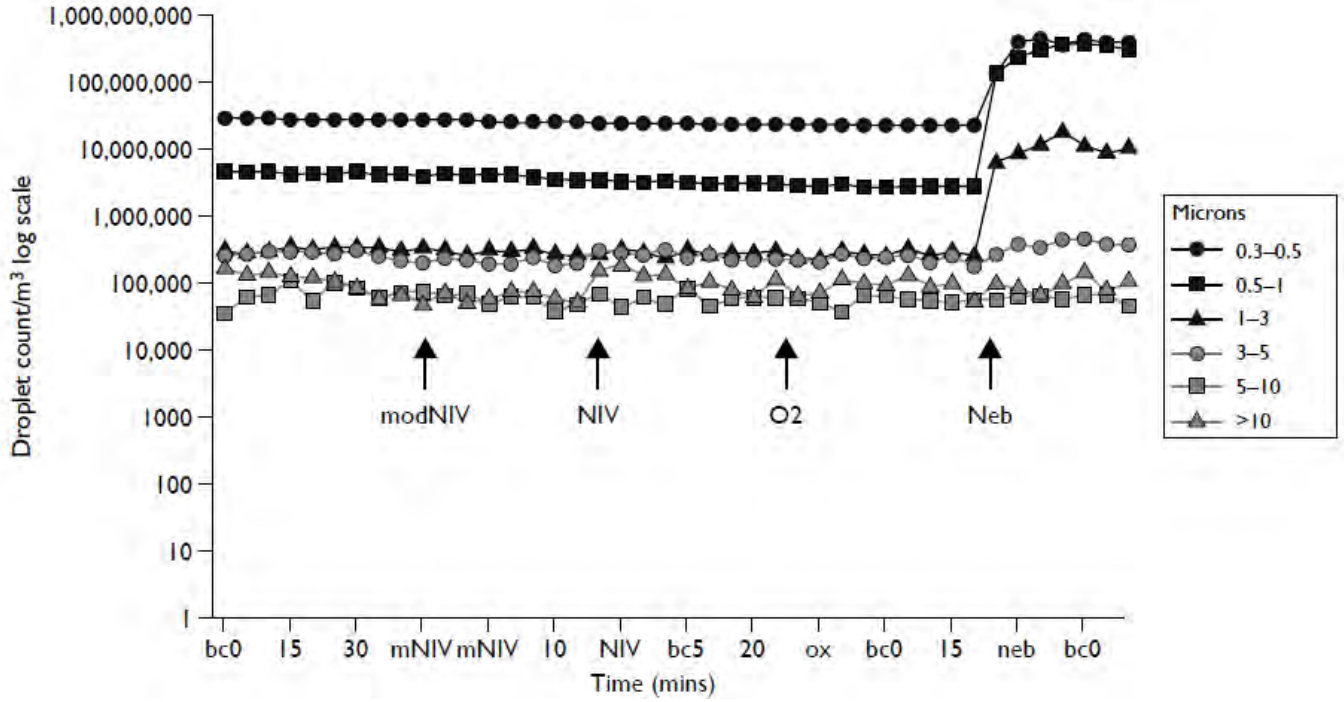
Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebuliser treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections

AK Simonds,[1]* A Hanak,[1] M Chatwin,[1] MJ Morrell,[1] A Hall,[2] KH Parker,[3] JH Siggers[3] and RJ Dickinson[3]

Health Technology Assessment 2010; 14(46), 131–172

Three groups were studied:

- (1) normal controls,
- (2) subjects with coryzal symptoms
- (3) adult patients with chronic lung disease who were admitted to hospital with an infective exacerbation.



Nebulised saline delivered droplets in the small and medium-size aerosol/droplet range, but did not increase large-size droplet count

TABLE 4 *Effect of intervention in droplet ranges D – difference between mean value pre and during intervention (continued)*

Microns	DI	0.3–0.5	0.5–1	1–3	3–5	5–10	>10	D2	0.3–0.5	0.5–1	1–3	3–5	5–10	>10
Physio														
Patient	D	–0.005	0.057	0.123	0.128	–0.010	**1.393**		–0.011	0.024	0.070	0.169	0.175	0.424
	p	0.610	0.118	0.164	0.260	0.511	**0.003**		0.702	0.206	0.151	0.134	0.228	0.158
Nebuliser														
Normal	D	**15.660**	**109.480**	**71.681**	**27.054**	**404.932**	**2.270**		**25.878**	**87.932**	**46.887**	**1.549**	0.232	0.207
	p	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**		**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.120	0.270
Patient	D	**15.516**	**91.193**	**56.320**	**3.967**	0.426	0.253		**23.080**	**90.576**	**45.920**	**1.642**	0.149	0.309
	p	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.111	0.261		**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.241	0.281
Coryzal	D	**11.204**	**64.822**	**38.341**	**1.871**	0.197	0.349		**17.994**	**49.458**	**30.454**	**1.144**	0.234	0.384
	p	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.229	0.192		**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.097	0.133

DI, distance 1; D2, distance 2; *p*, *p*-value.
p-values <0.05 are highlighted in bold text.

Clinical Infectious Diseases

MAJOR ARTICLE

IDSA Infectious Diseases Society of America

hivma hiv medicine association

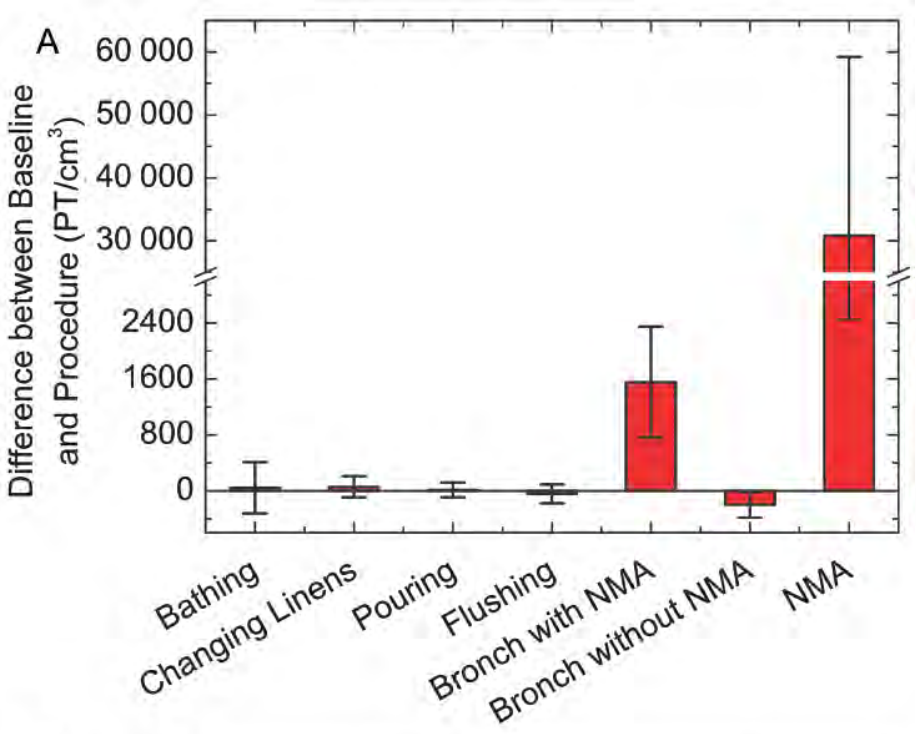
OXFORD

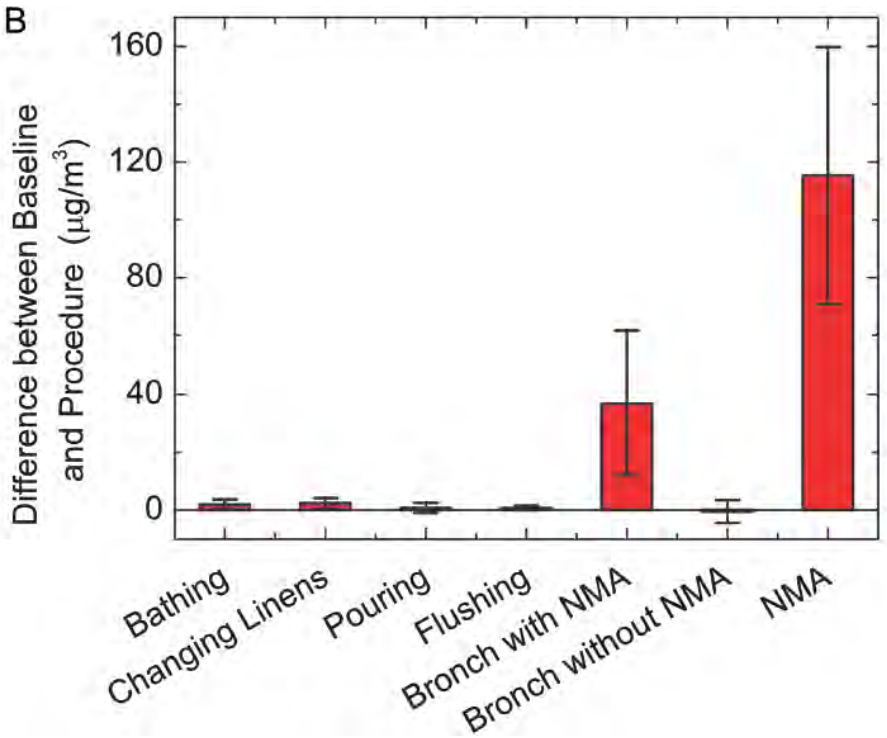
Characterization of Aerosols Generated During Patient Care Activities

Caroline A. O'Neil,[1] Jiayu Li,[2] Anna Leavey,[2] Yang Wang,[2] Matthew Hink,[1] Meghan Wallace,[3] Pratim Biswas,[2] Carey-Ann D. Burnham,[3] and Hilary M. Babcock[1]; for the Centers for Disease Control and Prevention Epicenters Program

[1]School of Medicine, Infectious Diseases Division, [2]School of Engineering and Applied Science, Department of Energy, Environmental, and Chemical Engineering, Aerosol and Air Quality Research Laboratory, and [3]School of Medicine, Department of Pathology and Immunology, Washington University, St Louis, Missouri

Clinical Infectious Diseases® 2017;65(8):1342–8





pharmaceutics

MDPI

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Article

Investigation of the Quantity of Exhaled Aerosols Released into the Environment during Nebulisation

James A. McGrath [1,*], Andrew O'Sullivan [2], Gavin Bennett [2], Ciarraí O'Toole [1], Mary Joyce [2], Miriam A. Byrne [1] and Ronan MacLoughlin [2]

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[2] Aerogen, IDA Business Park, Dangan, Galway H91 HE94, Ireland; andrewosullivanjr@gmail.com (A.O.); GBennett@aerogen.com (G.B.); MJoyce@aerogen.com (M.J.); RMacLoughlin@aerogen.com (R.M.)

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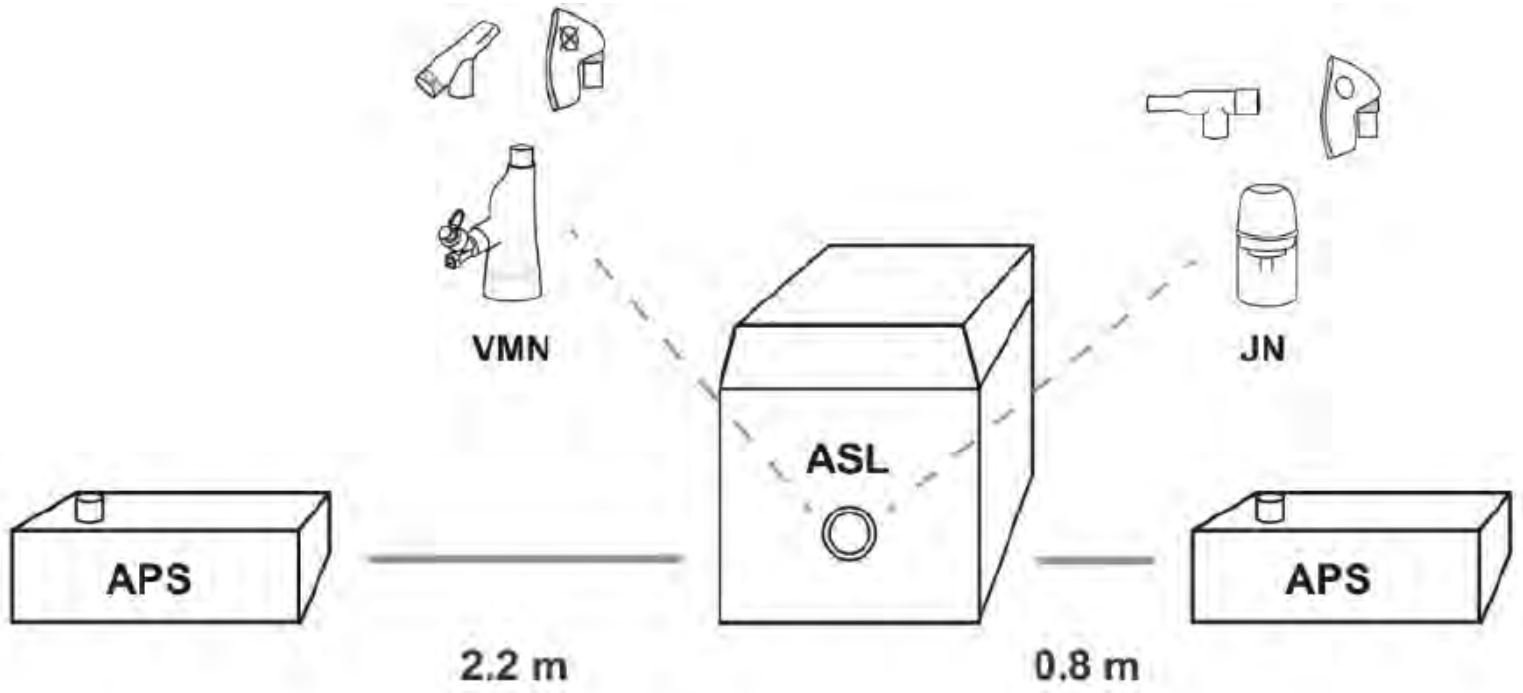
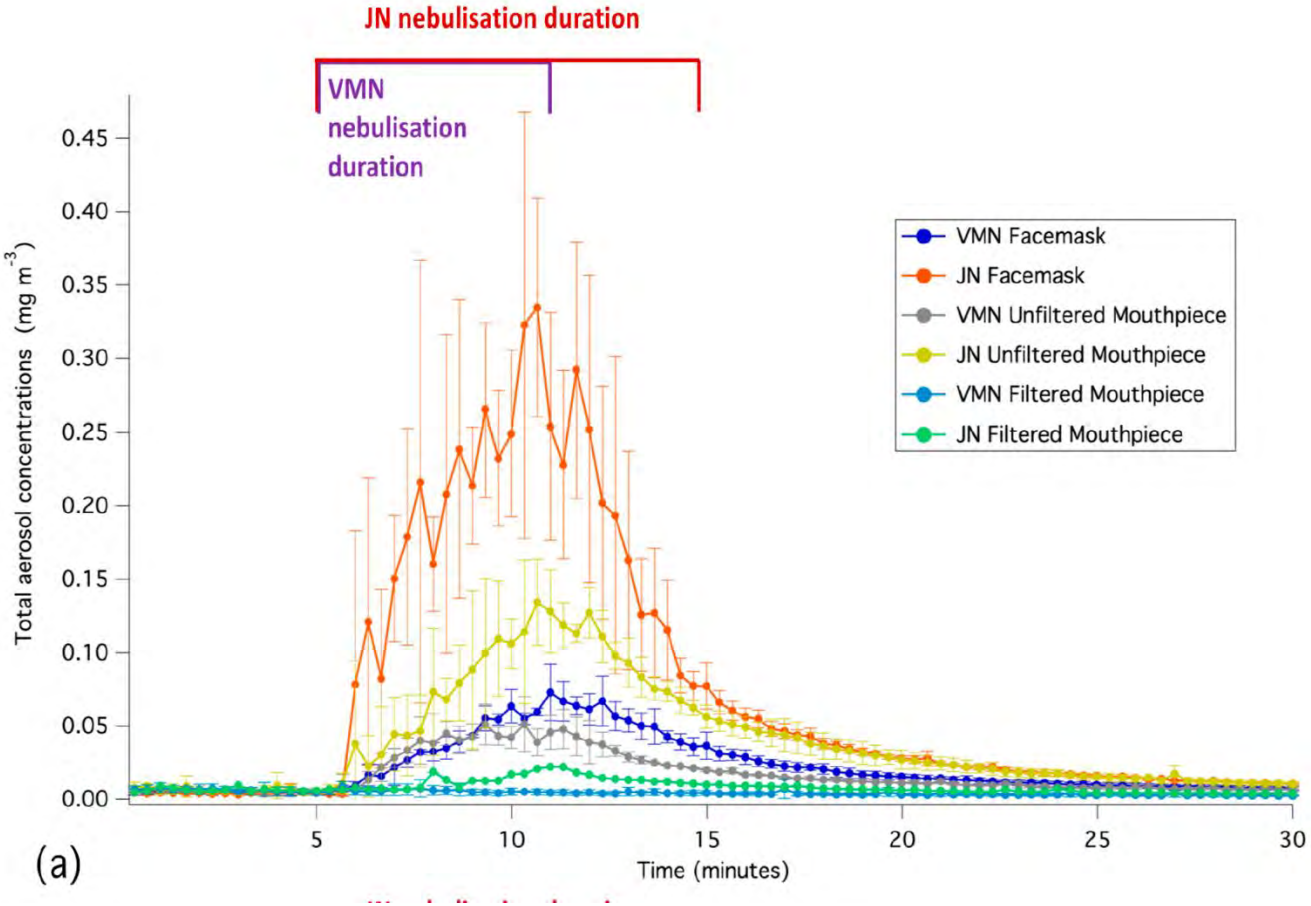
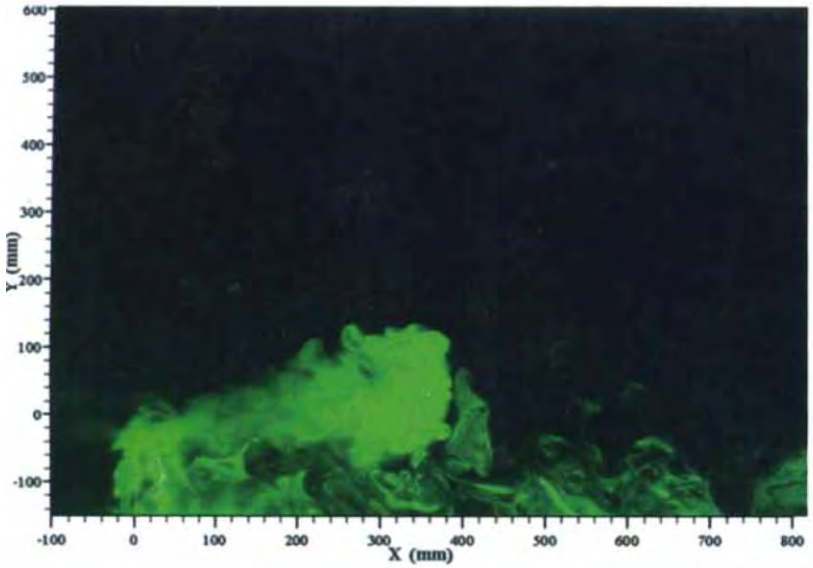
Pharmaceutics **2019**, 11, 75

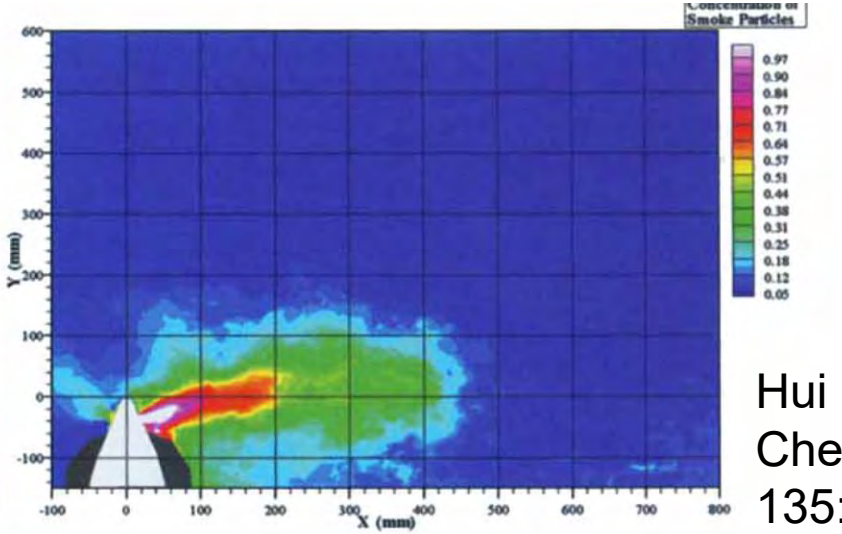




Nebuliser Type	Facemask (mg m^{-3})	Unfiltered Mouthpiece (mg m^{-3})	Filtered Mouthpiece (mg m^{-3})
Jet Nebuliser	0.072 ± 0.001	0.039 ± 0.004	0.009 ± 0.001
Vibrating Mesh Nebuliser	0.022 ± 0.001	0.017 ± 0.002	0.004 ± 0.001

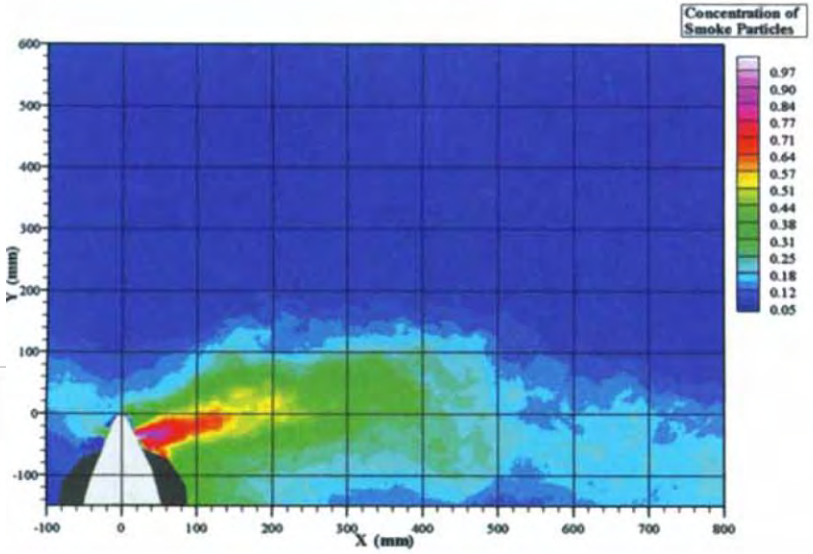
Nebulization



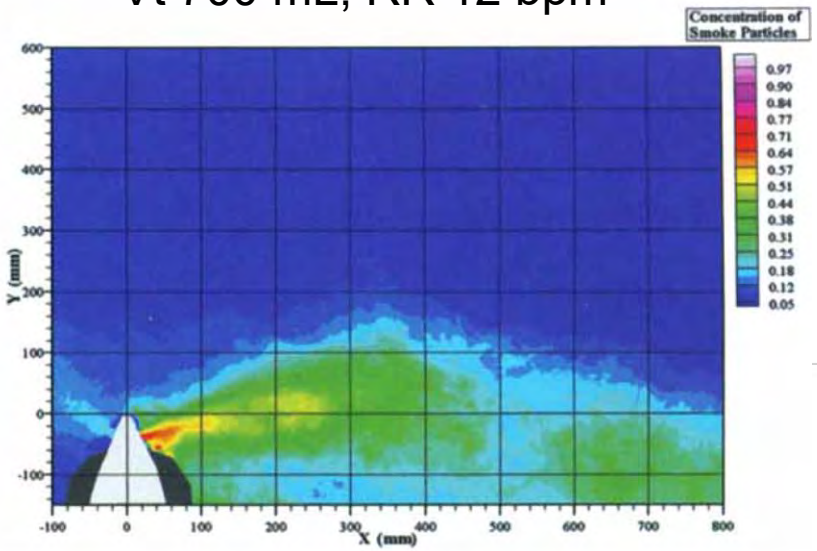


Hui et al. Chest 2009; 135: 648-654.

Vt 700 mL, RR 12 bpm



Vt 300 mL, RR 25 bpm



Vt 150 mL, RR 40 bpm

Table 2—*A Summary of Maximum Exhaled Air Dispersion Distances During Application of Different Types of Respiratory Therapy to the HPS Under Different Lung Settings

NPPV (Mild Lung Injury)†		Simple Oxygen Mask (Mild Lung Injury)‡		Jet Nebulizer Driven by Air at 6 L/min (Current Study)	
IPAP/EPAP, cm H_2O	Distance, m	L/min	Distance, m	Injury	Distance, m
10/4	0.40	4	0.20	Normal	0.45
14/4	0.42	6	0.22	Mild lung injury	0.54
18/4	0.45	8	0.30	Severe lung injury	> 0.80
		10	0.40		

Comments

- All the studies only reported the aerosol concentration in the ambient air increased during nebulization
  - Expected, as this is the purpose of the treatment
  - None of them can differentiate medical aerosol vs bioaerosol

Resolution

- Avoid unnecessary nebulization and cough inducing aerosolized medication including hypertonic saline, as it is high-risk transmission procedure
- For spontaneous breathing patients
  - Preferred MDI+Spacer;
  - If MDI is not available, or medication is in the form of solution
    - VMN with handheld and mouthpiece/mask (preferred mouthpiece and place a filter at the other end of mouthpiece), oxygen flow set at 2-8 L/min
    - In-line placement of VMN with HFNC, place surgical mask on patient's face during nebulization;
  - If SVN is the only choice, use one-way valve SVN set up or connect a filter to SVN
- For invasively ventilated patients: place mesh nebulizer at the inlet of humidifier to deliver aerosol therapy

Place a nebulizer in-line with HFNC

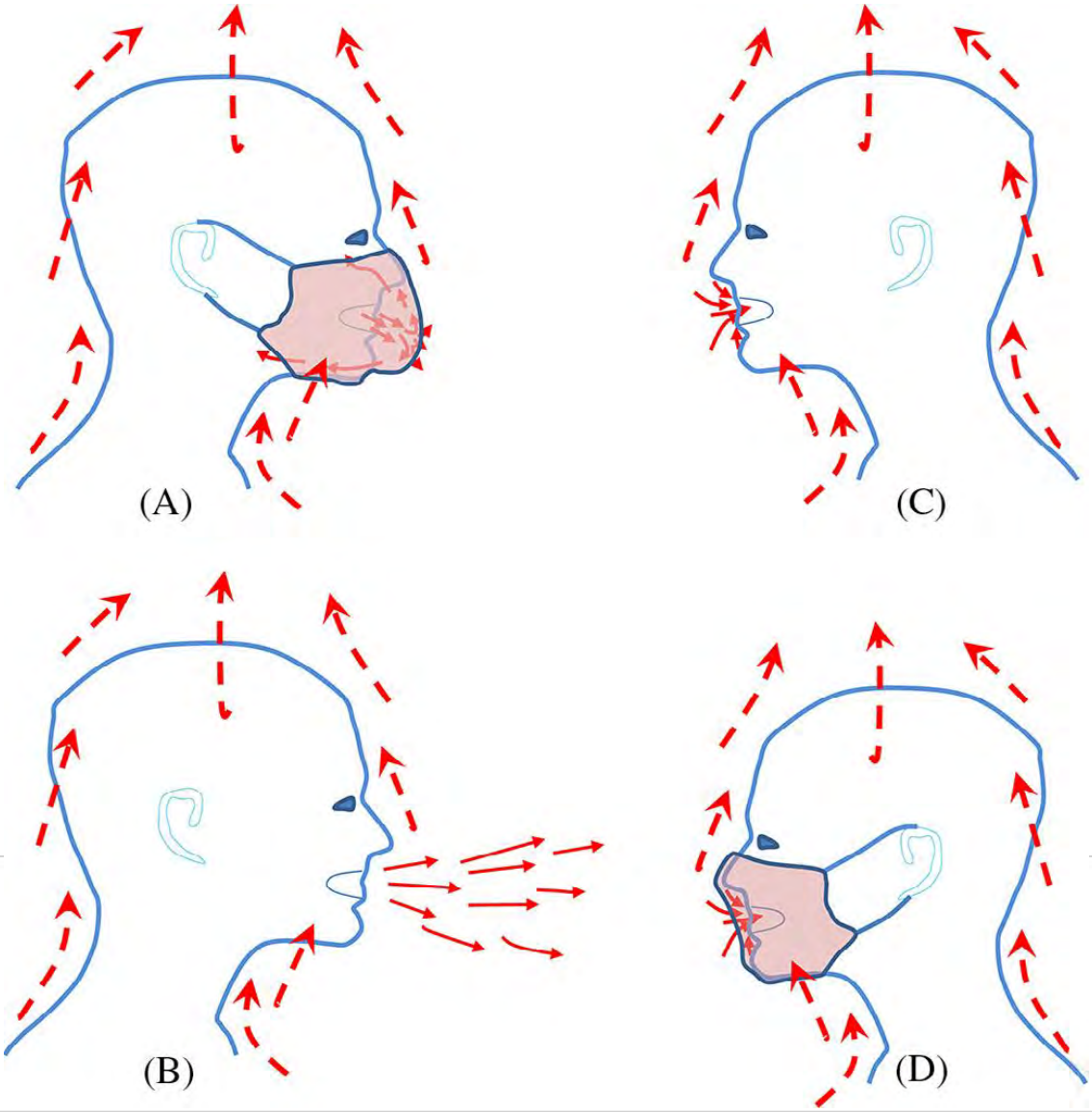
VS

Inhaled dose in vivo scintigraphy study: 17.23 ± 6.78%

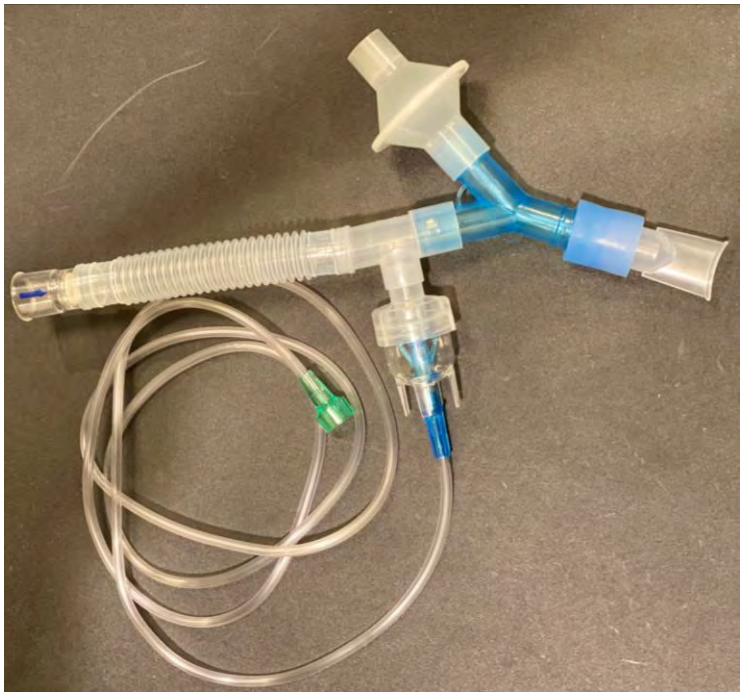
Pharmaceutics 2019;11(7): 320

Inhaled dose: 10-20%

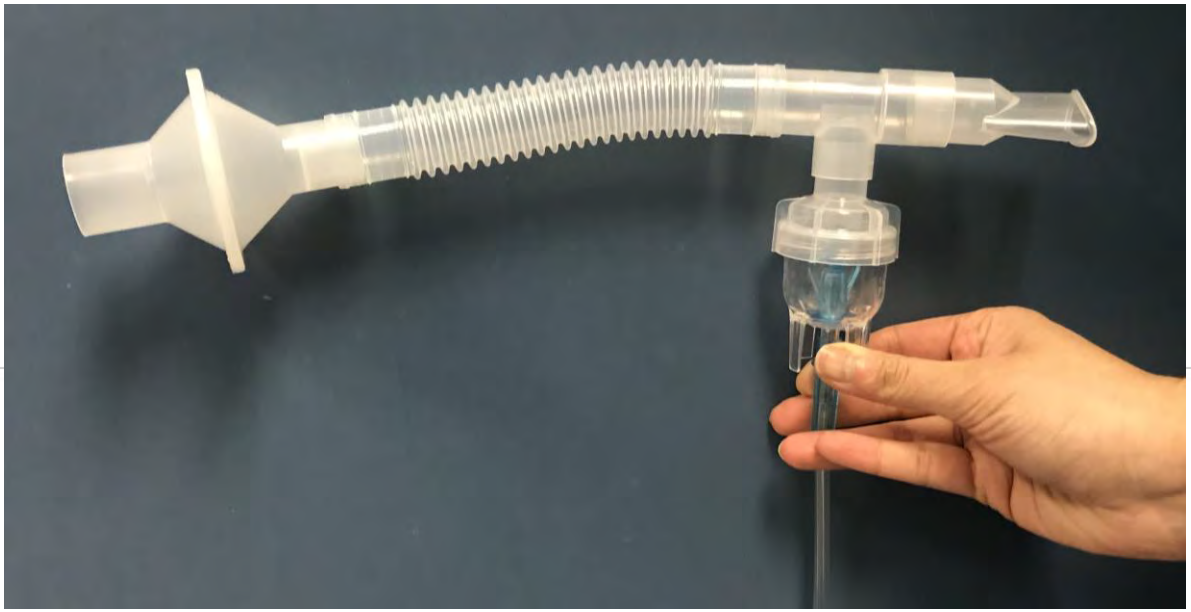
Effects of wearing a mask



American Journal of Infection Control 2016; 44: S102-S108



One-way valve with SVN set up



SVN with filter

Cough & wearing a mask

Table 1. Efficacy of surgical and N95 masks to filter influenza in point-of-care assay–positive patients.

Patient or variable	Influenza type	Cycle number: Nasal swab	No mask, before control (step 1)	N95 mask (step 2)	Surgical mask (step 3)	No mask, after control (step 4)	Duration of illness, days per week
Patient							
1	A	31	38	Negative	Negative	39	3
2	A	26	40	Negative	Negative	Negative	1
3	A	22	Negative	Negative	Negative	40	3
4	A	26	34	Negative	Negative	35	1
5	A	23	32	Negative	Negative	33	2
6	A	25	27	Negative	Negative	25	1
7	B	22	38	Negative	Negative	27	2
8	A	29	34	Negative	Negative	Negative	3
9	B	27	Negative	Negative	Negative	39	3
Mean cycle time for patients with detected influenza A	...	26[a]	34.17[a]	0	0	34.4[a]	2[b]
Estimated viral load for detected influenza A, copies/mL	...	5 million[a]	50,000[a]	0	0	50,000[a]	...

Step: (1) coughing without a mask (before control)
(2) coughing while wearing a fitted N95 mask
(3) coughing while wearing a routine surgical mask
(4) coughing without a mask (after control)

Johnson et al, Brief report
2009, 49: 275

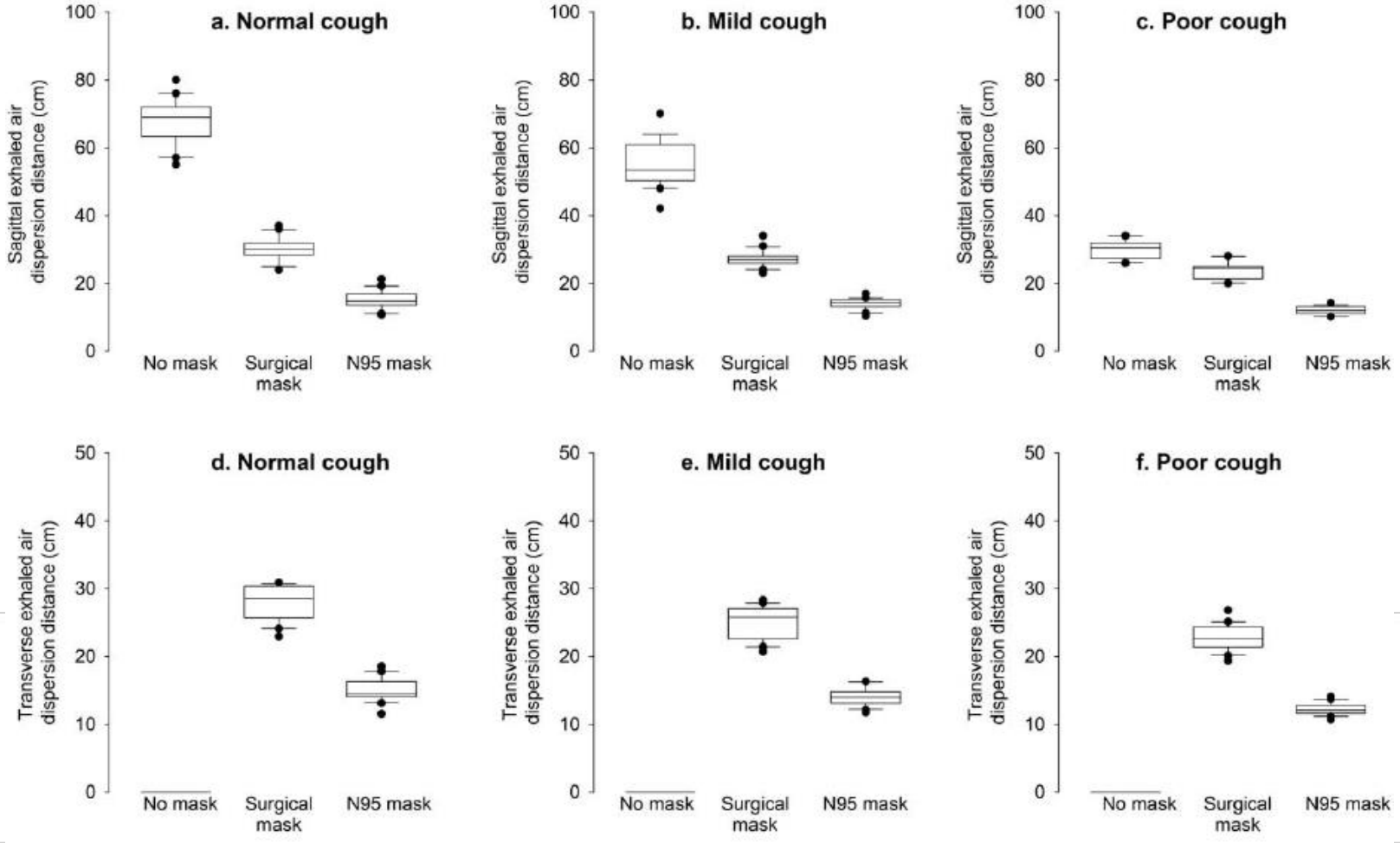
Exhaled Air Dispersion during Coughing with and without Wearing a Surgical or N95 Mask

SITY
TER

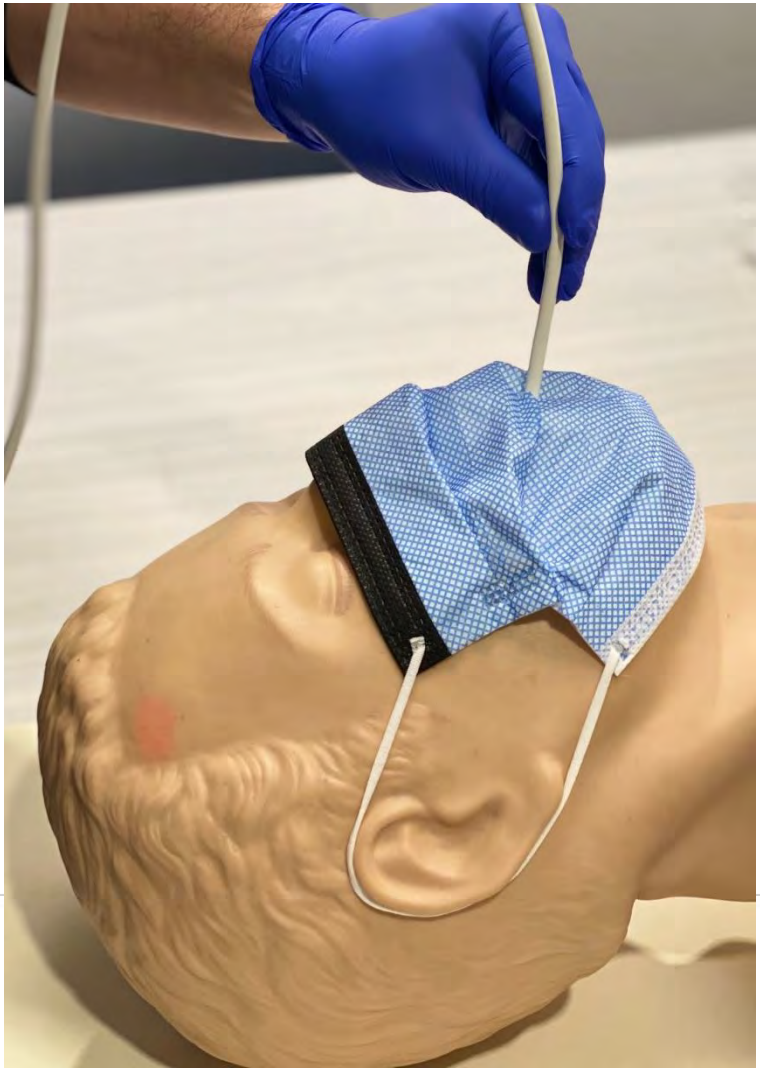
David S. Hui[1,2*], Benny K. Chow[2,3], Leo Chu[4], Susanna S. Ng[1], Nelson Lee[1,2], Tony Gin[4], Matthew T. V. Chan[4]

Plus one 2012; 7(12): e50845.

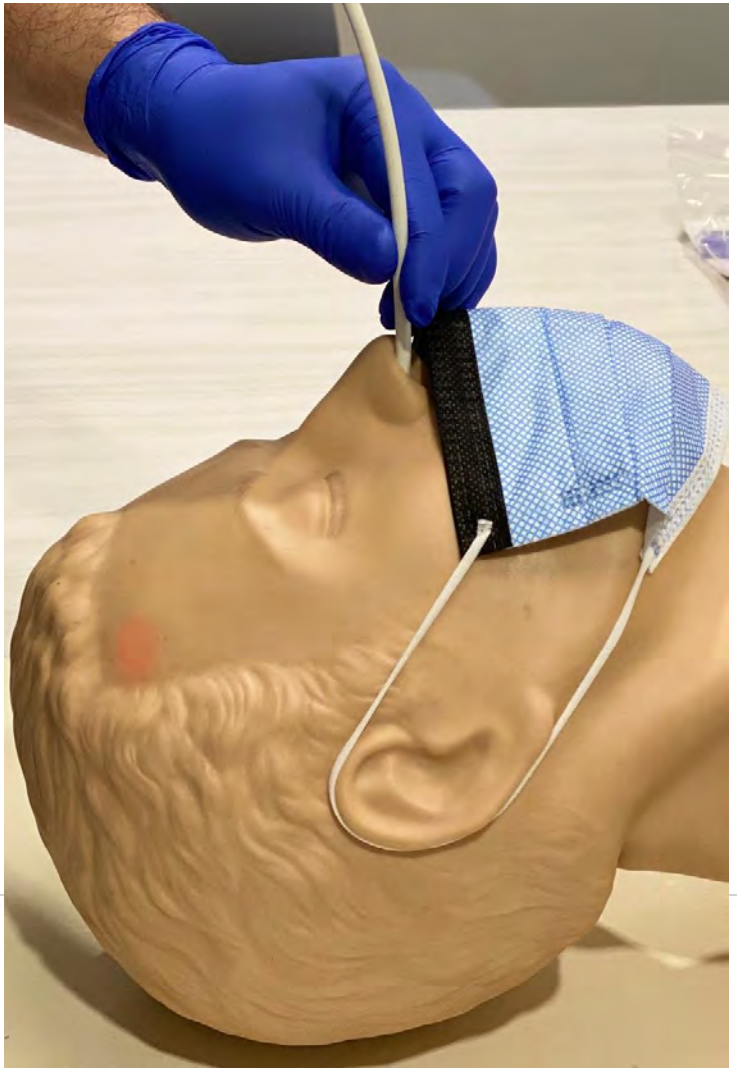
1 Department of Medicine and Therapeutics, The Chinese University of Hong Kong, Hong Kong SAR, The People's Republic of China, **2** Stanley Ho Center for Emerging Infectious Diseases, The Chinese University of Hong Kong, Hong Kong SAR, The People's Republic of China, **3** Center for Housing Innovations, The Chinese University of Hong Kong, Hong Kong SAR, The People's Republic of China, **4** Department of Anaesthesia and Intensive Care, The Chinese University of Hong Kong, Hong Kong SAR, The People's Republic of China



Recommendation for bronchoscopy examination



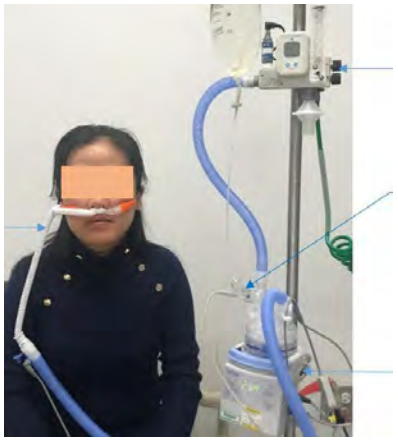
Bronchoscope inserted via mouth



Bronchoscope inserted via nose

Oxygen therapy

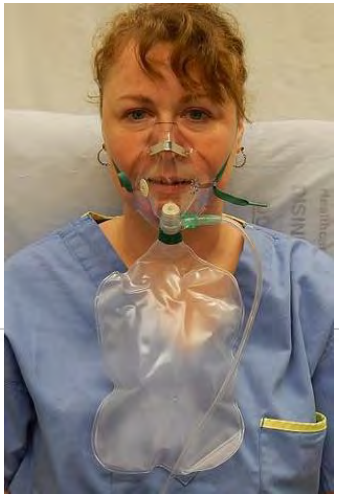
Nasal cannula



High-flow nasal cannula

Simple mask

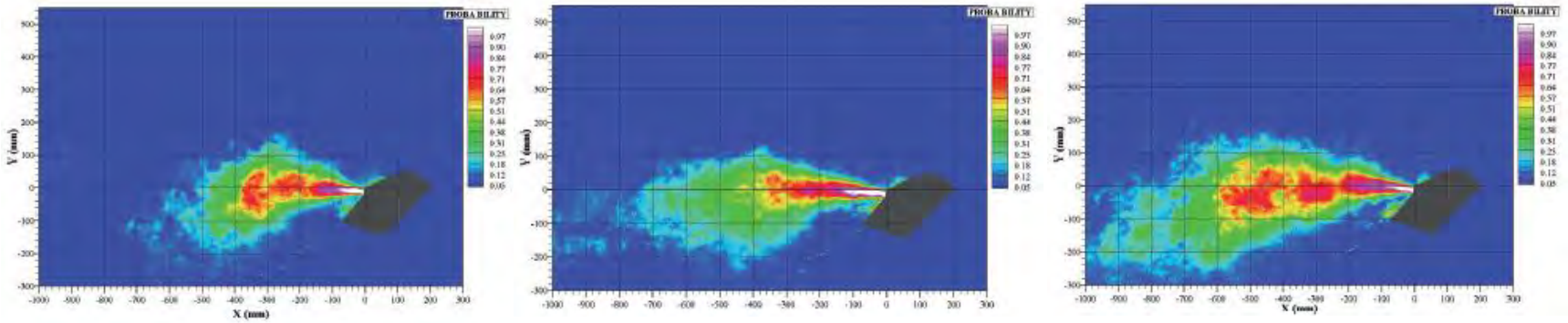
Venturi mask



Nonbreather mask

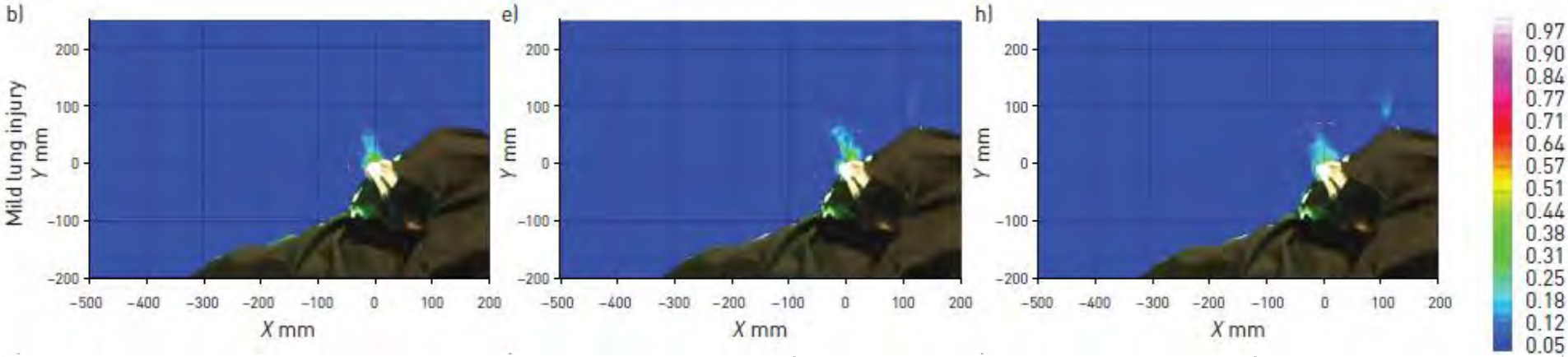
Lung condition	Oxygen device		Dispersion distance, cm
Normal	HFNC	60 L/min	17.2 ± 3.3
		30 L/min	13.0 ± 1.1
		10 L/min	6.5 ± 1.5
	Simple mask	15 L/min	11.2 ± 0.7
		10 L/min	9.5 ± 0.6
	Nonrebreather mask	10 L/min	24.6 ± 2.2
	Venturi 40%	6 L/min	39.7 ± 1.6
	Venturi 35%	6 L/min	27.2 ± 1.1
Mild	HFNC	60 L/min	7.2 ± 1.8
		30 L/min	6.1 ± 1.7
		10 L/min	4.3 ± 1.0
	Nasal cannula	1 L/min	66
		3 L/min	70
		5 L/min	100
	Simple mask	15 L/min	20.7 ± 1.2
		10 L/min	12.5 ± 0.8
	Nonrebreather mask	10 L/min	24.6 ± 2.2
	Venturi 40%	6 L/min	39.7 ± 1.6
	Venturi 35%	6 L/min	33.8 ± 1.4
Severe		60 L/min	4.8 ± 1.6
		30 L/min	3.7 ± 1.2
		10 L/min	3.0 ± 0.8

HFNC vs standard nasal cannula



1 L/min 3 L/min 5 L/min

Hui et al, Respirology (2011) **16**, 1005–1013



10 L/min 30 L/min 50 L/min

Hui et al. Eur Respir J 2019; 53: 1802339

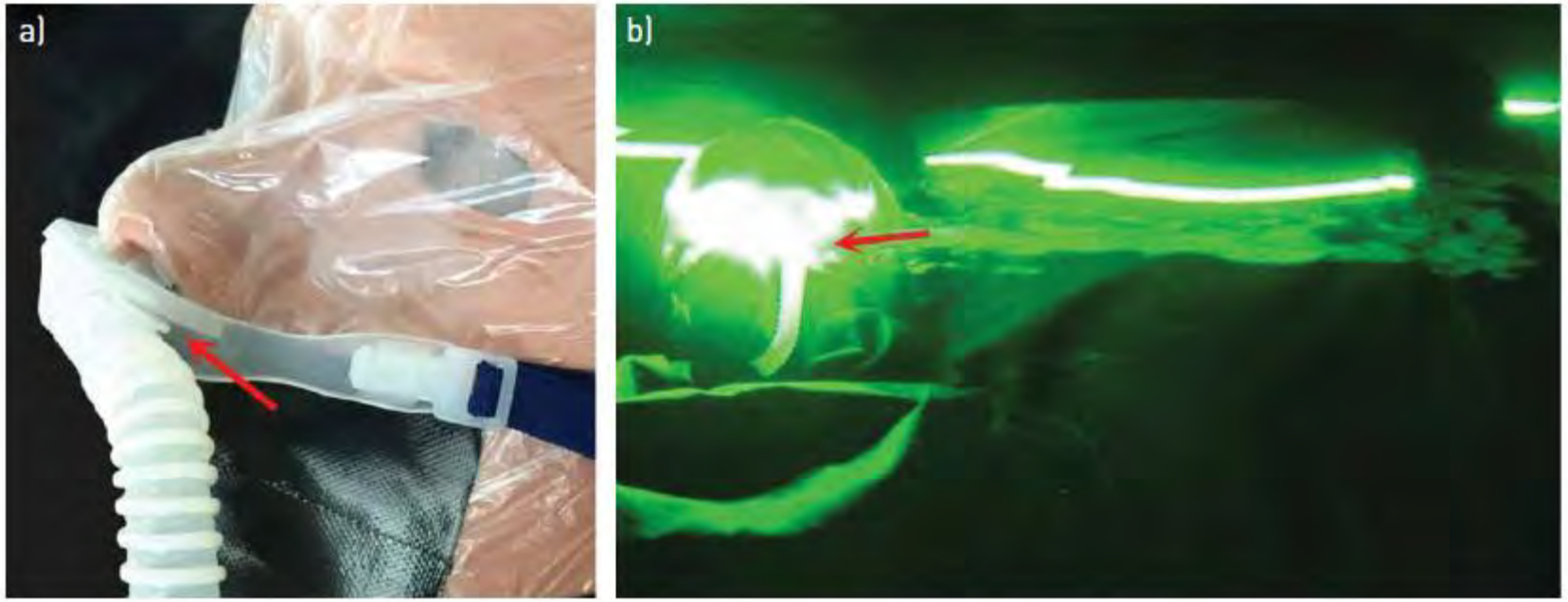
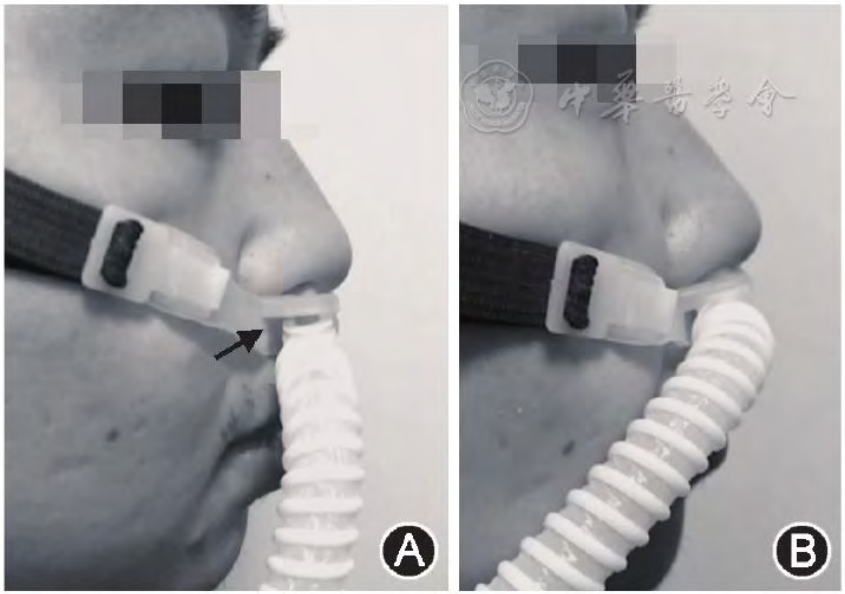


FIGURE 3 a) A loose connection (arrow) between the high-flow nasal cannula (60 L·min^{-1}) and the interface tube. b) This resulted in exhaled air leakage to 620 mm laterally.



Zhonghua Jie He He Hu Xi Za Zhi. 2020 Mar 12;43(3):189-194.

In vivo study

Journal of Hospital Infection 101 (2019) 84–87

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

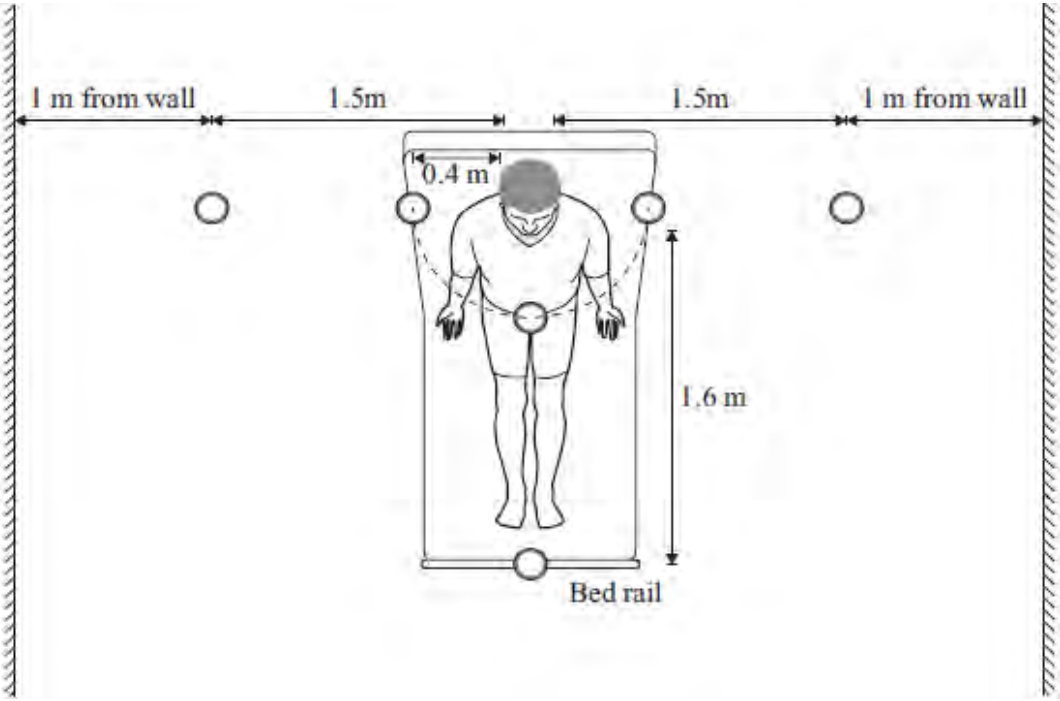
Short report

Comparison of high-flow nasal cannula versus oxygen face mask for environmental bacterial contamination in critically ill pneumonia patients: a randomized controlled crossover trial

C.C.H. Leung[a], G.M. Joynt[a,*], C.D. Gomersall[a], W.T. Wong[a], A. Lee[a], L. Ling[a], P.K.S. Chan[b], P.C.W. Lui[c], P.C.Y. Tsoi[c], C.M. Ling[b], M. Hui[b]

[a] Department of Anaesthesia and Intensive Care, The Chinese University of Hong Kong, Hong Kong
[b] Department of Microbiology, The Chinese University of Hong Kong, Hong Kong
[c] Department of Pathology, Union Hospital, Hong Kong

J of Hospital Infection 2019;(101): 84 – 87.



19 patients were enrolled

- The mean (SD) age was 59 (14) years.
- Eight patients were female.
- 1 community acquired in one patient and 18 hospital-acquired.
- The mean (SD) APCHE II score was 20.1 (4.1), SOFA score 3.4 (2.1) and PaO2/FiO2 ratio 276.7 (114.1) mmHg [6,7].
- Mean (SD) oxygen flow rate for oxygen mask was 8.6 (2.2) L/min and the FiO2 while using HFNC was 0.5 (0.1) at 60 L/min.

Result

Gram-negative bacterial count and total bacterial count by device (air sampling and settle plate), air changes per hour, and days of incubation ($N = 19$)

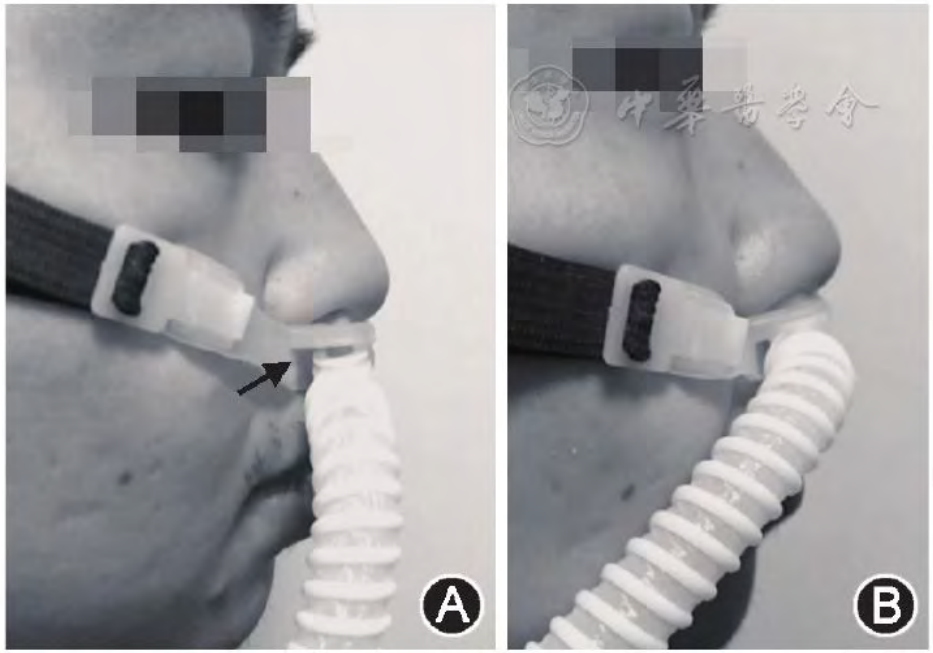
Sample	ACH	1-day incubation			2-day incubation			5-day incubation		
		HFNC	OM	*P*-value	HFNC	OM	*P*-value	HFNC	OM	*P*-value
Gram-negative bacteria										
Air (cfu/m^3)	6	0 (0–0)	0 (0–0.1)	0.770	0 (0–0)	0 (0–0)	0.208	0 (0–0.1)	0 (0–0.05)	0.250
	12	0 (0–0)	0 (0–0)	0.167	0 (0–0)	0 (0–0)	0.902	0 (0–0)	0 (0–0)	0.416
0.4 m settle plate	6	0 (0–0)	0 (0–0)	0.862	0 (0–0)	0 (0–0.2)	0.568	0 (0–0)	0 (0–0)	0.250
(cfu/plate)	12	0 (0–0)	0 (0–0)	0.3925	0 (0–0)	0 (0–0)	0.500	0 (0–0.3)	0 (0–0)	0.119
1.5 m settle plate	6	0 (0–0)	0 (0–0)	0.207	0 (0–0)	0 (0–0)	0.573	0 (0–0)	0 (0–0)	0.207
(cfu/plate)	12	0 (0–0)	0 (0–0)	0.500	0 (0–0)	0 (0–0)	0.500	0 (0–0)	0 (0–0)	0.500
Total bacterial count										
Air (cfu/m^3)	6	1.7 (1.0–4.3)	2.4 (1.1–4.2)	0.707	3.6 (2–6.9)	3.8 (1.9–5.5)	0.700	5.2 (2.2–8.7)	4.5 (1.7–9.6)	0.105
	12	1 (0.5–1.7)	1.3 (0.5–2.0)	0.915	1.6 (1.0–2.7)	1.9 (1.1–3.1)	0.776	2.1 (1.0–4.2)	2.3 (0.9–3.5)	0.205
0.4 m settle plate	6	1.7 (0.7–4.5)	1.3 (0.7–2.0)	0.428	3.7 (0.8–7.2)	2 (0.7–2.8)	0.287	4.3 (1.3–6.0)	2.0 (1.0–5.0)	0.175
(cfu/plate)	12	0.7 (0.2–1.8)	1 (0.3–2.2)	0.175	1 (0.8–1.5)	2 (0.7–3.2)	0.987	1.7 (0.7–3.3)	2.0 (1.0–3.3)	0.186
1.5 m settle plate	6	1.0 (0.5–1.8)	0.3 (0.3–0.8)	0.0385	1.3 (1–2.7)	0.7 (0.3–1.3)	0.010	1.7 (1.3–3.0)	1.3 (0.3–2.3)	0.091
(cfu/plate)	12	0.7 (0.2–0.8)	0.3 (0–1)	0.387	0.7 (0.3–1.2)	1 (0.3–1.3)	0.786	0.7 (0.3–1.7)	1.0 (0.3–2.7)	0.187

ACH, air changes per hour; HFNC, high-flow nasal cannulae; OM, oxygen mask; cfu, colony-forming units.
Values for HFNC and OM are median (interquartile range).
All statistical tests one-tailed.

Post-hoc analysis

- The TBC on settle plates placed at 0.4 m was higher than at 1.5 m with either device (P = 0.002-0.037)
- higher at six ACH than at 12 ACH with either device (P = 0.000- 0.002).

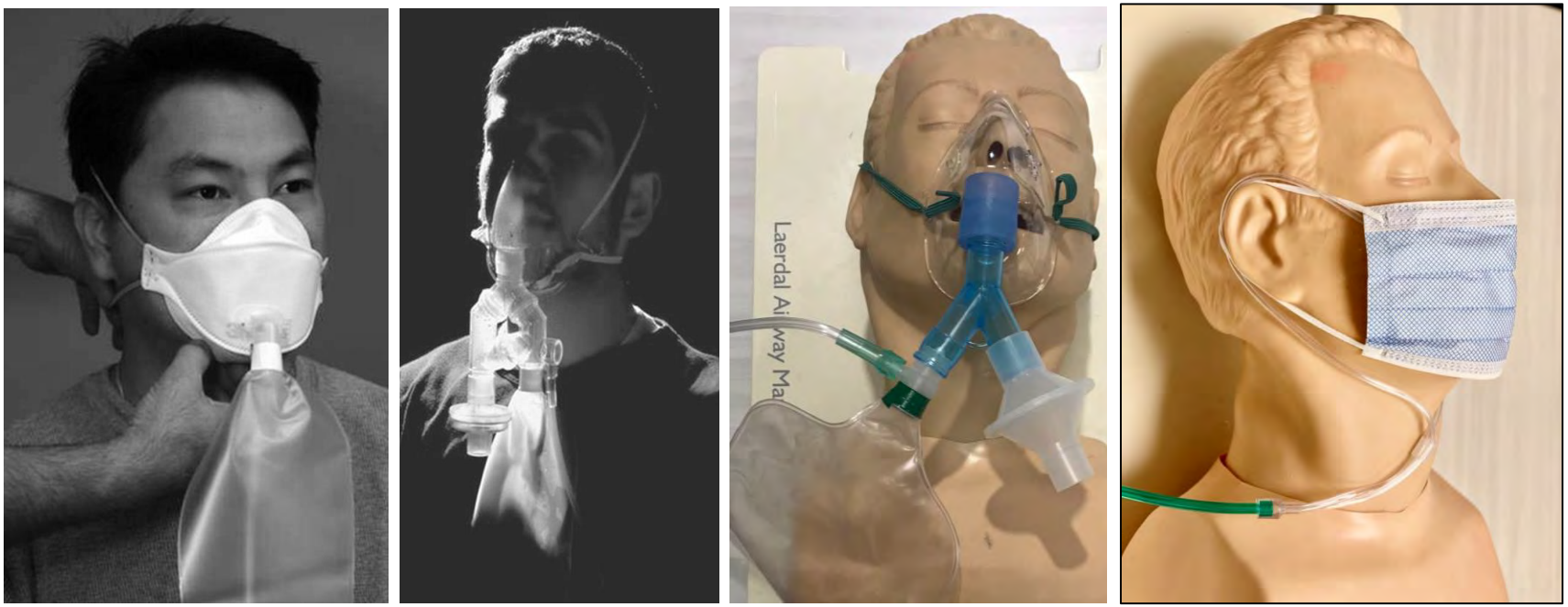
Resolution



- Wear a surgical mask for patients during HFNC therapy
- Connect nasal cannula tightly

Respiratory care committee of Chinese Thoracic Society. Zhonghua Jie He He Hu Xi Za Zhi. 2020 Feb 20;17(0):E020

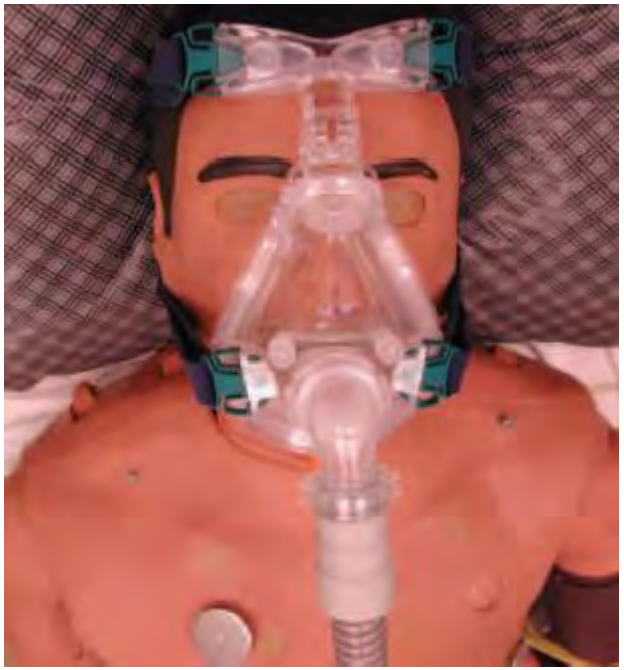
Recommendation



Daugherty et al, Respir Care 2008;53(2):201–212.

- Use high flow nasal cannula (6-15 L/min, Salter lab) with patient wearing a surgical mask
- Place a filter on oxygen mask, avoid using Venturi mask

Noninvasive ventilation



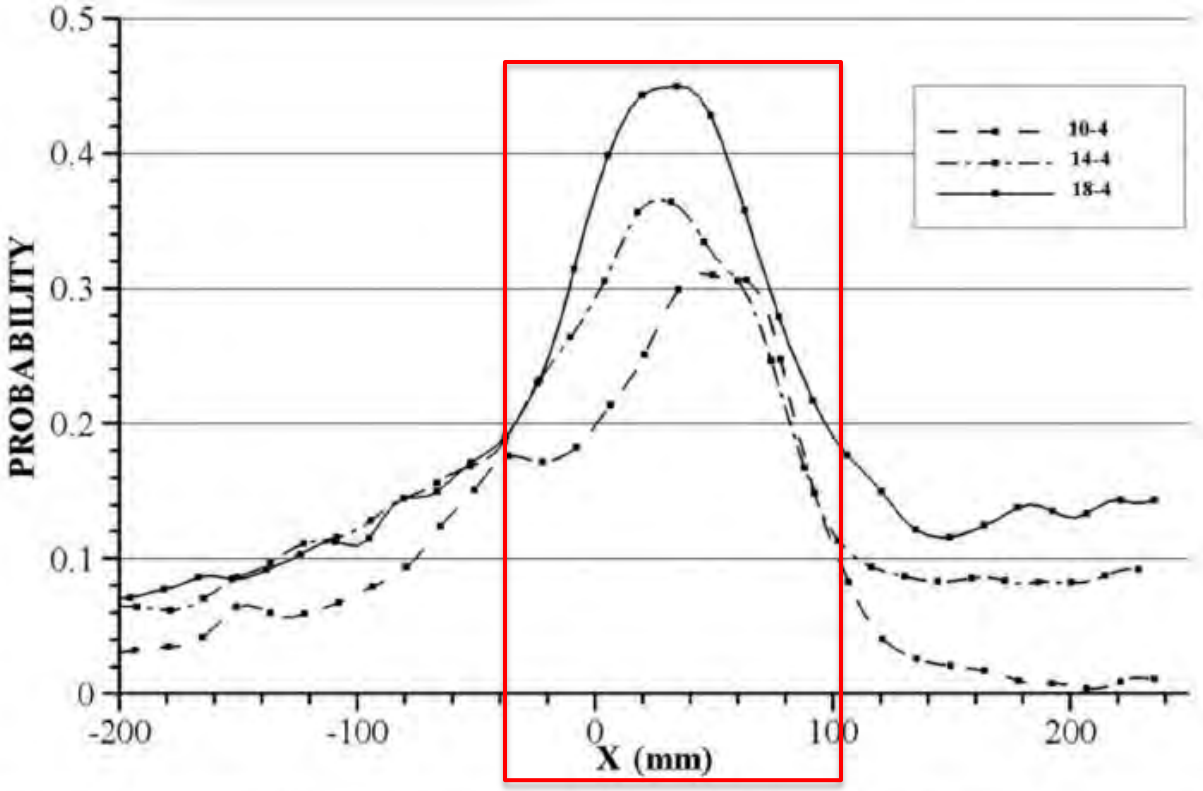
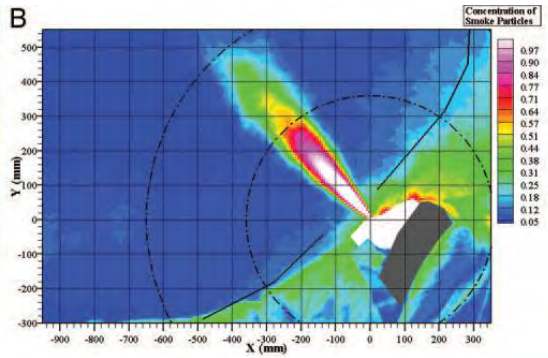
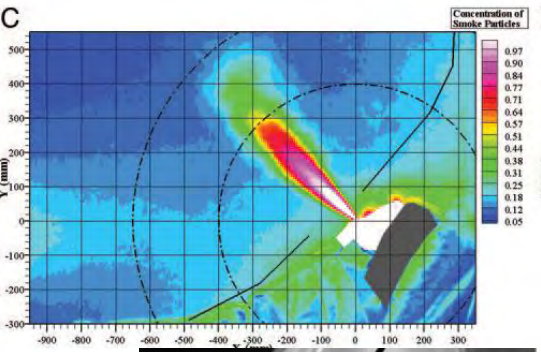


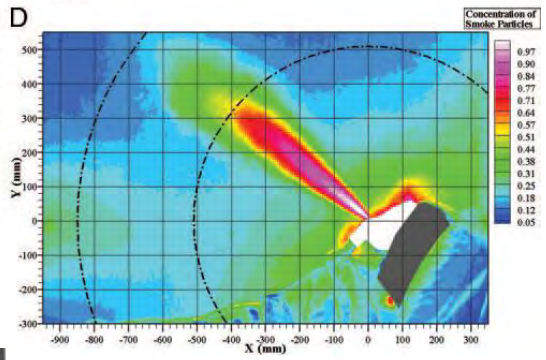
FIGURE 6. The profile of concentration probability along a line 300 mm above the mask (y = 0 mm on contours and x is the horizontal coordinate, exactly as in the contour plots) is plotted for each of the three IPAP settings (*ie*, 10, 14, and 18 cm H_2O), whereas EPAP was maintained at 4 cm H_2O. The variation in the shapes represented a turbulent jet flow, which was highly variable.

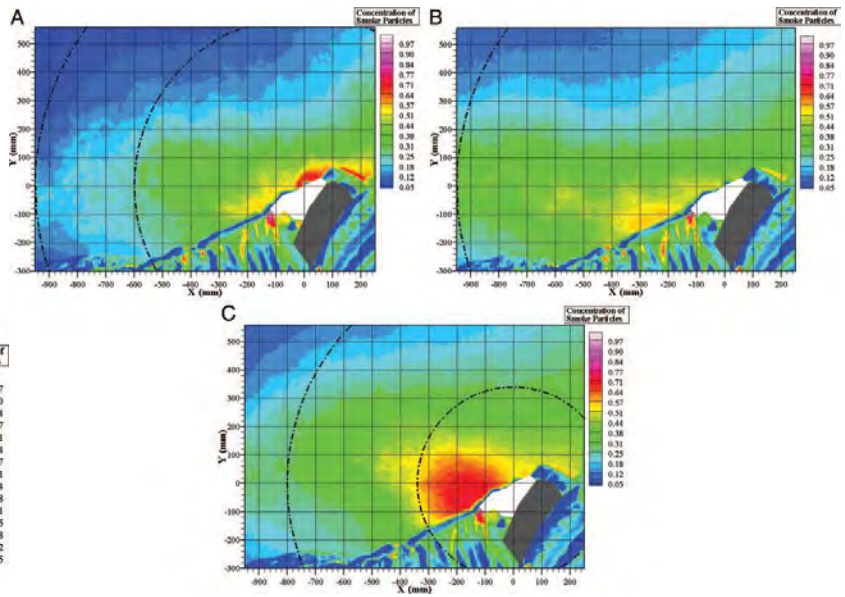
Hui et al, Chest 2006; 130:730–740

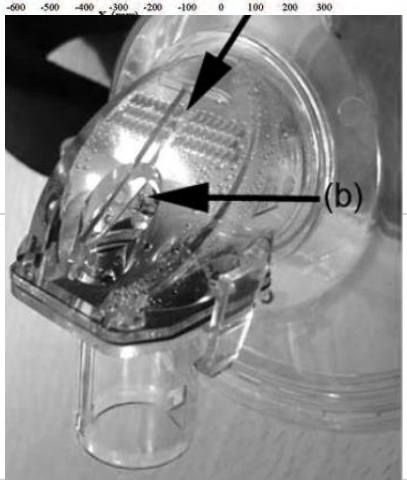
Comparison of different masks











ComfortFull 2 mask

Hui et al, Chest 2009; 136:998–1005

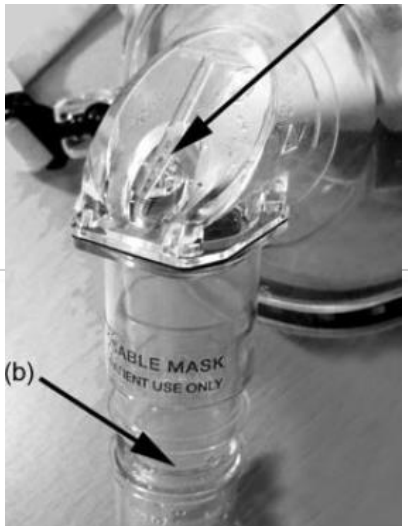


Image 3 mask

Different CPAP settings and interfaces

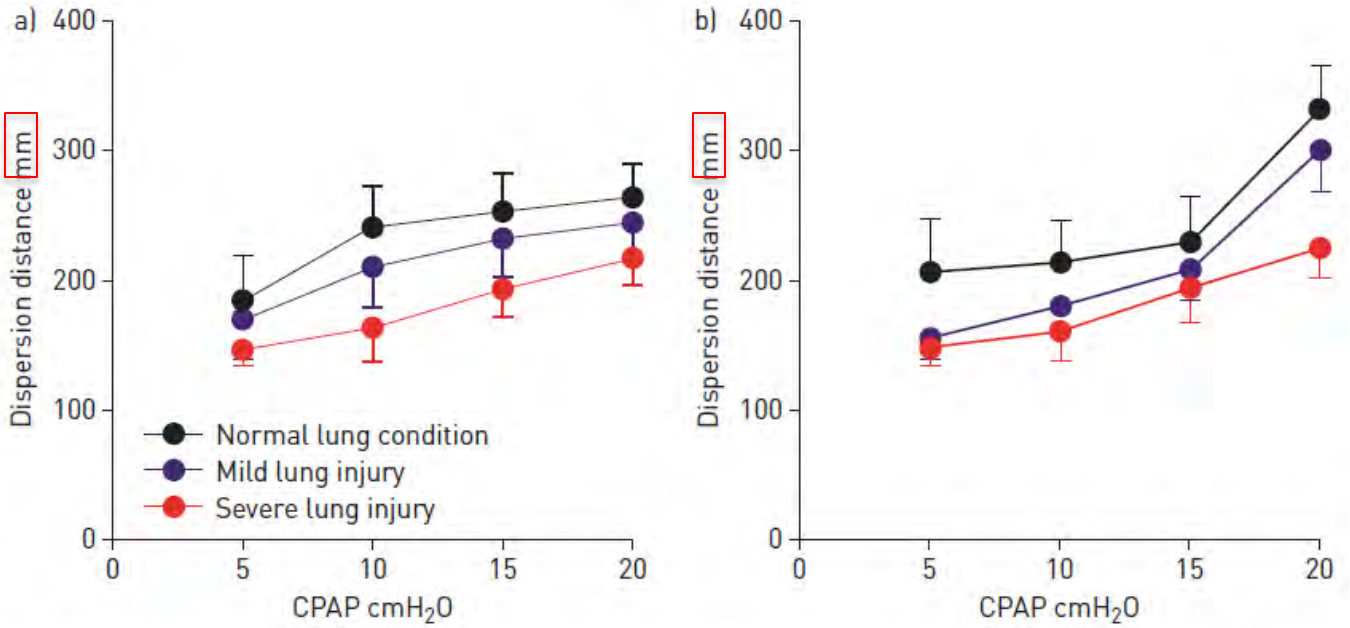


FIGURE 4 Changes of exhaled air dispersion with increasing continuous positive airway pressure (CPAP) and worsening degree of lung injury in a) Respironics Nuance Pro Gel and b) ResMed Swift FX nasal pillows.

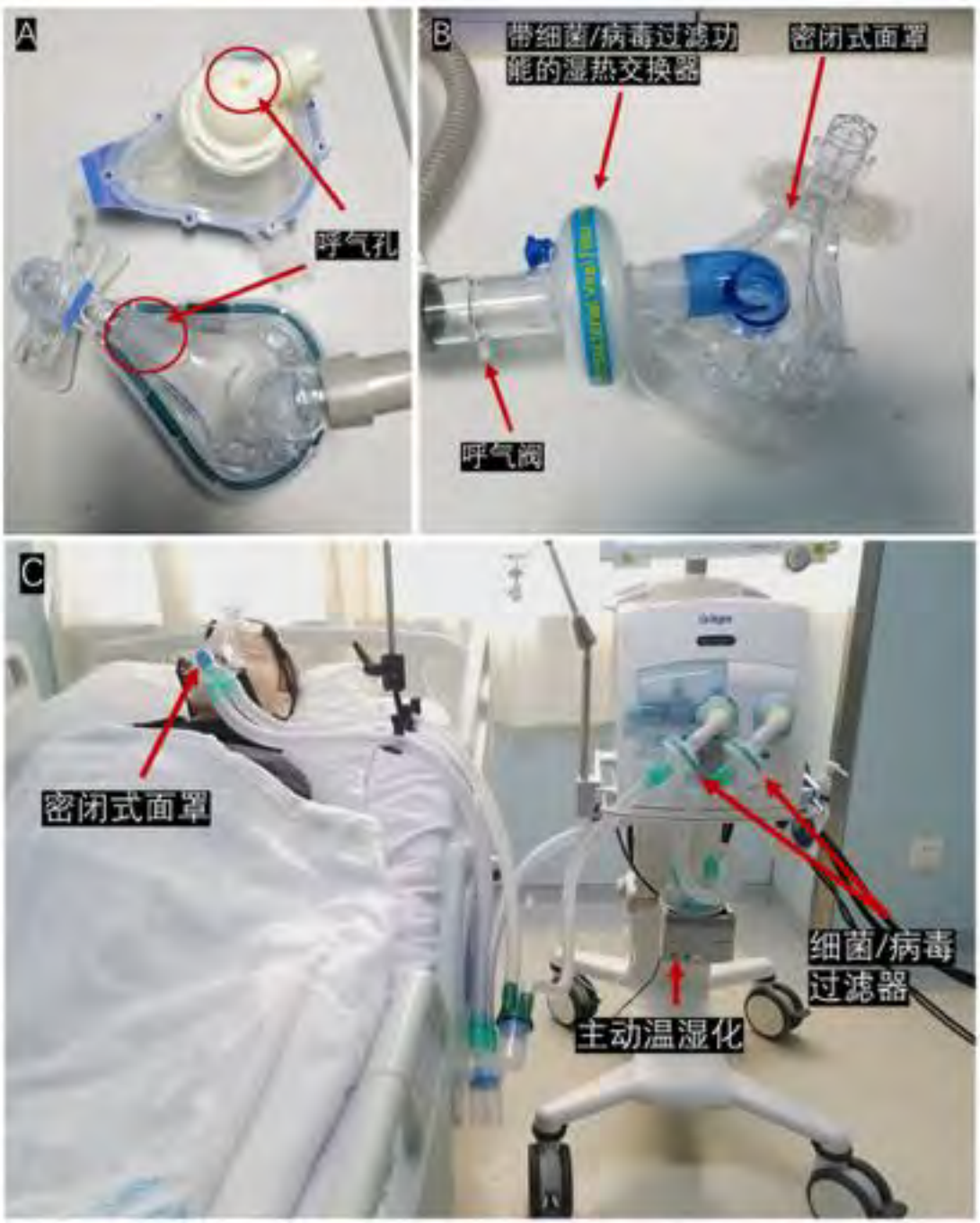
Eur Respir J 2019; 53: 1802339

In vivo study

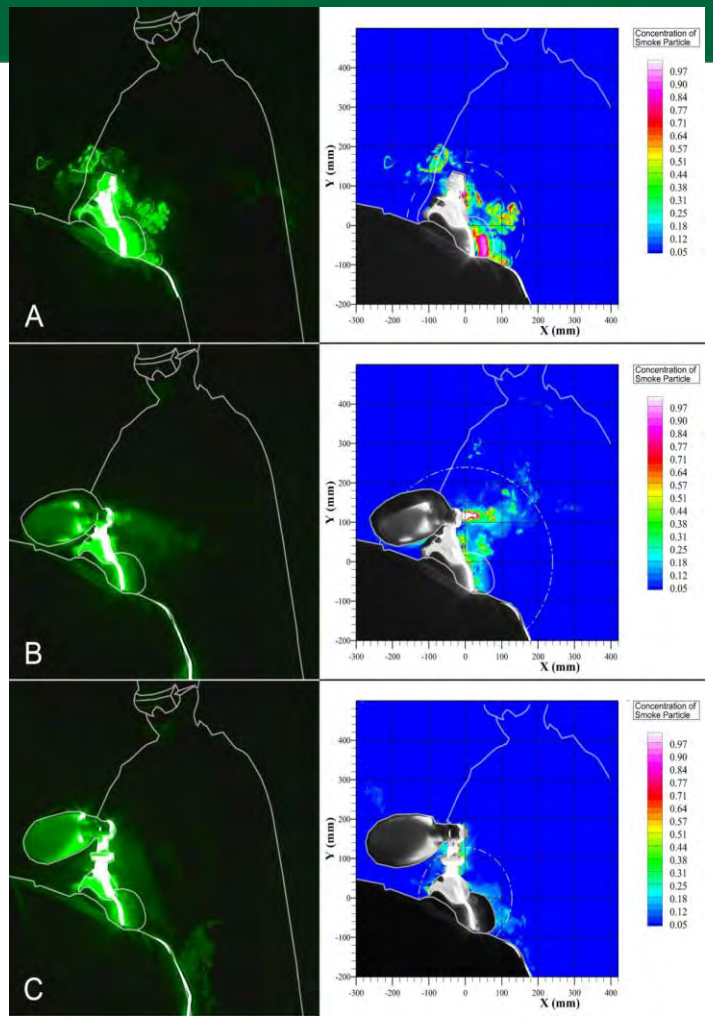
- Compared with baseline values
  - NIV using a vented mask produced droplets in the large size range (> 10 μm) in patient (p = 0.042) and coryzal subjects (p = 0.044)
    - this increase was not seen using the NIV circuit modification with non-vented mask and exhalation filter
  - but not in normal controls (p = 0.379)

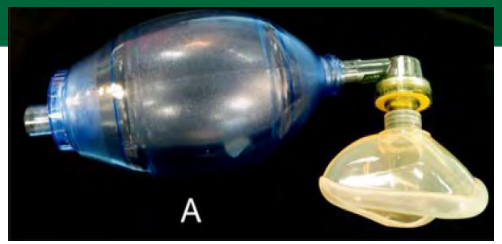
Health Technology Assessment 2010; 14(46), 131–172

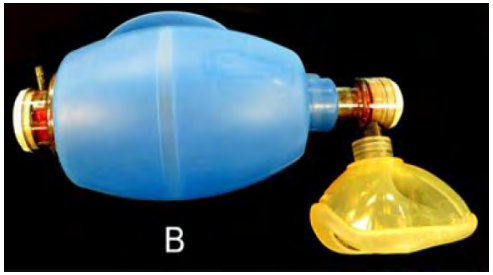
Resolution

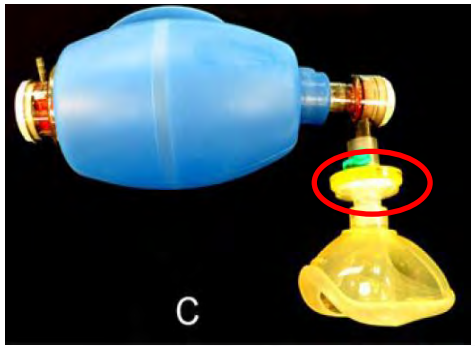


- Mask fit is critical, if full face mask is not fit, consider using Total face mask to get sealed
- Avoid using vent mask with expiratory port on the mask
- For short-term use, place a filter between mask and expiratory port in the single limb ventilator, avoid using humidification
- For long-term use or patient complaints dry gas, use dual limb vent and provide humidification







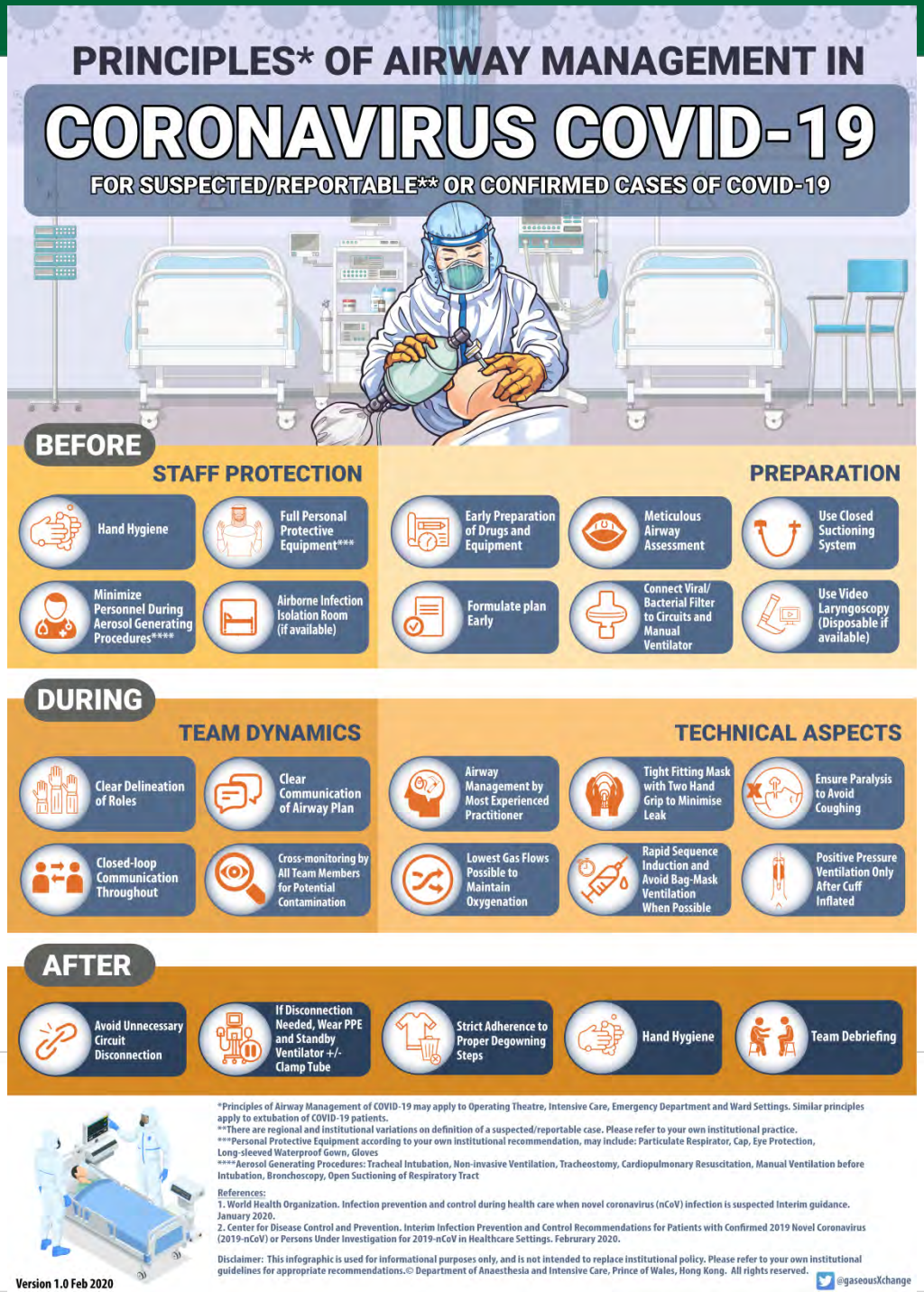


Manual ventilation

- Place filter between resuscitator and mask
- Tight seal resuscitator mask when it is utilized

Group	No. of providers	Exhaled air dispersion distance (mm)*		
		Laerdal silicone resuscitator	Ambu silicone resuscitator	Ambu silicone resuscitator with addition of breathing filter
Anesthesiologists/Intensivists	5	161 ± 5	242 ± 20	128 ± 21
Respiratory physicians	5	187 ± 17	210 ± 48	148 ± 17
Nurses	5	230 ± 47	267 ± 44	241 ± 62
Medical students	5	175 ± 54	234 ± 51	129 ± 33

Chan et al, Scientific reports *(2018) 8:198*



Department of intensive care unit, Prince of wales hospital, Hongkong, China

Personal protection equipment

	Infected Staff (n=13)	Non-infected staff (n=241)	p*	Odds ratio (95% CI)†
Protective measures‡				
Masks§	2 (15%)	169 (70%)	0·0001	13 (3–60)
Paper mask	2	26	0·511¶	
Surgical mask	0	51	0·007¶	
N95	0	92	0·0004¶	
Gloves	4 (31%)	117 (48%)	0·364	2 (0·6–7)
Gowns	0 (0%)	83 (34%)	0·006	NC
Hand-washing	10 (77%)	227 (94%)	0·047	5 (1–19)
All measures	0 (0%)	69 (29%)	0·022	NC

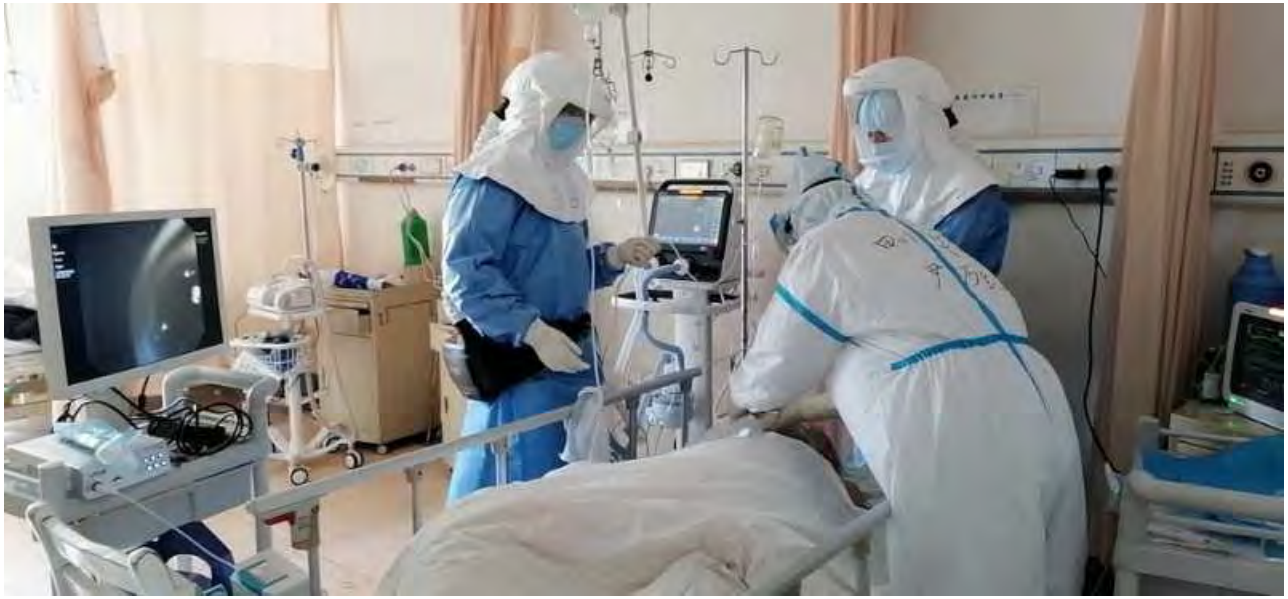
Lancet 2003; 361:1519-20.

Personal protection equipment (PPE)

- N95 respirator/surgical mask for airborne/droplet precautions
- Contact precautions: Disposable gloves, gown, cap
- Eye protection with non-reusable goggles and face-shield
- Powered air purification respirators (PAPR) may be used when performing high-risk procedures (Figs 1a and 2a)
- Pens, paper, other personal items and medical records should not be allowed into or removed from the room
- Immediate removal of grossly contaminated PPE and showering in nearby facility

Respirology 2003; **8**: S31–S35

PPE




3M
8210V
NIOSH
TC-84A-5410
N95
WARNING
This respirator helps protect against
certain particles. Misuse may result in


MAXAIR

Thanks for listening!

A Chinese respiratory therapist stopped transportation to view the lingering light of the setting sun with a COVID-19 patient

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