Bilaga 3
Risk för smittspridning vid behandling med nebulisator eller högflödesgrimma (2020), Upplysningstjänstsvar ut202022

Bilaga 3 Tabell över studier utan försökspersoner

SBU Statens beredning för medicinsk och social utvärdering • www.sbu.se
Telefon 08-412 32 00 • **Fax** 08-411 32 60 • **Organisationsnummer** 202100-4417
Besöksadress S:t Eriksgatan 117, Stockholm • **Postadress** Box 6183, 102 33 Stockholm

Author Year Reference	Aim	Equipment/ Setting	Exposure/dose	Measures	Findings	Authors Conclusion
Ari et al 2016 [1]	Secondhand aerosol exposure during mechanical ventilation with and without expiratory filters (no measures at mask)	Two categories of ventilators were tested: Experiment 1: Ventilators without filters in the expiratory limb: The Servo-i (Maquet Inc, Wayne, NJ) and the Galileo (Hamilton Medical, Reno, NV), A filter was placed at the exhaust port. Experiment 2, A ventilator with a proprietary filter in the expiratory limb: PB 840 (Covidien-NellcorTM and Puritan BennettTM, Boulder, CO). Two filters were attached to the ventilators without proprietary filters: at the end of expiratory limb and at the exhaust outlet. Location: not reported	The test lung operated with VT 500 ml, RR 20 bpm, PIF 50 L/min, PEEP 5 cm H2O. Four separate doses of albuterol (2.5 mg/3 mL) were administered via jet nebuliser (eValueMed, Tri-anim) placed at the "Y". In Experiment 1, a filter (Respirgard 303) was placed at the exhaust port.	Drug was eluted from filters and measured using spectrophotometry.	Drug deposited at the exhaust port without expiratory filtering was >160 fold higher than with expiratory filtering. Regardless of type of filter used, placement of filter in the expiratory limb reduced secondhand aerosol exposure significantly.	Risk of secondhand exposure to exhaled aerosol can account for >45% of nominal dose as well as droplet nuclei produced by patients. Using expiratory filters decreases risk of exposure to aerosol released to the atmosphere during mechanical ventilation
Bennet et al 2018 [2]	Effect of tidal volume on fugitive emissions during mechanical ventilation	Aerosol was delivered during simulated adult mechanical ventilation. (Bellavista 1000, IMT Medical, Switzerland).	Ventilator conditions: two tidal volumes calculated based on a standard 69 kg adult, 276 mL and 828 mL (4 mL per kg and 12 mL per kg respectively).	Mass concentrations were recorded using two Aerodynamic Particle Sizer's at two distances from the ventilator.	Aerosol mass concentration at 0.8 m: Volume 1: (276 mL)=0.064±0.004 and Volume 2: (828 mL)	Aerosol mass concentrations were significantly greater when a tidal volume of 828 mL was used in comparison to 276 mL, thus indicating

		The nebuliser was placed on the humidified inspiratory limb.	4 mg of salbutamol was nebulised using a vibrating mesh nebuliser.		A=0.094±0.002 (P-value 0.004) Aerosol mass concentration at 2.2 m: Volume 1: (828mL)=0.052±0.002 and volume 2: (828 mL)=0.077±0.005 (P-value 0.013)	that aerosol emissions are influenced by ventilator parameters. At higher tidal volumes, the increased exhaled volume results in a greater quantity of aerosol being released. These findings support the often ignored recommendation for placement of a filter on the expiratory limb of the circuit, in an effort to reduce emissions during mechanical ventilation
Hui et al 2009 [3]	Exhaled Air and Aerosolized Droplet Dispersion During Application of a Jet Nebulizer	Jet nebulizer (Salter Labs; Arvin, Cal) and Human patient simulator (HPS) (HPS 6.1; Medical Education Technologies Inc.; Sarasota, FL). Airflow was marked with intrapulmonary smoke. Hospital isolation room with a pressure of - 5 Pa	The jet nebulizer: air at a constant flow rate of 6 L/min with the mask reservoir filled with sterile water and attached to the HPS via a nebulizer mask.	The maximum dispension distance of smoke particles through the nebulizer side vent: measured by laser light sheet and images (high-definition video). Smoke concentration in the plume measured by light scattered by smoke and droplet particles.	At normal lung condition (oxygen consumption, 200 ml/min; lung compliance, 70 ml/cm H2O): 0.45 m lateral to the HPS. At mild lung injury (oxygen consumption, 300 ml/min; lung compliance, 35 ml/cm H2O): 0.54 m. At severe lung injury (oxygen consumption, 500 ml/min; lung compliance, 10 ml/cm H2O): beyond 0.8 m.	Health-care workers should take extra protective precaution within at least 0.8 m from patients with febrile respiratory illness of unknown etiology receiving treatment via a jet nebulizer even in an isolation room with negative pressure.
Hui et al 2011 [4]	Exhaled air dispersion distances during oxygen delivery via nasal cannula to a human-	Human-patient simulator (HPS) Nasal cannula attached to the nostrils of the HPS	HPS set to mimic 70 kg male, positioned sitting at 45°. Oxygen flow was delivered at 1, 3 and 5 L/min.	Exhaled air dispersion distances at different oxygen flow rates were captured using the laser smoke visualization method. A thin laser light-	Room A: an exhalation jet spread almost horizontally outward from the nostrils of the HPS to 0.66 m and 1 m towards the end of bed	Substantial exposure to exhaled air occurs within 1 m towards the end of the bed from patients receiving oxygen via nasal cannula. Room dimension

	patient simulator (HPS) in two different isolation rooms		Room A: 4.1 x 5.1 x 2.6 m, ventilator system pressure: -7.4 Pa and 16 air exchanges per hour (ACH) Room B: 2.7 x 4.2 x 2.4 m, ventilator system pressure: -5 Pa and 12 ACH	sheet was used, and images were captured by a high-definition videocamera. Data from at least 20 breathing cycles for each oxygen flow rate was analyzed	when oxygen flow was increased from 1 to 5 L/min respectively. Room B: interaction between the ventilation current and the exhaled air from the HPS caused deflection of exhaled smoke towards the head of the HPS at an oxygen flow rate of 1 L/min	and air exchange rate are important factors in preventing contamination in isolation rooms.
Hui et al 2014 [5]	Aerosol dispersion during various respiratory therapies. We studied the deliberate leakage from the exhalation ports of mask 1 and 2	Jet nebuliser and various oxygen masks (ComfortFull 2 and Image 3 masks, Respironics, Murrysville) High-fidelity HPS (Medical Education Technologies, Sarasota [FL], USA). All tested in Double-door, negative pressure (–5 Pa) isolation rooms measuring 2.8 x 4.22 x 2.4 m. Except Venturi mask that was tested on a general medical ward.	HPS set to mimic 70 kg male, positioned sitting at 45°. Conditions varied from normal to severe lung injury mild lung injury mode.	The maximum dispersion distance of smoke particles was measured by laser light sheet and images (high-definition video). Smoke concentration in the plume measured by light scattered by smoke and droplet particles. The normalised concentration contours were made up of data collected from at least 20 breaths.	The maximum exhaled air distances during application of jet nebuliser and oxygen via nasal cannula, Venturi mask, and the non-rebreathing mask were about 0.8 m, 0.42 m, 0.4 m, and <0.1 m, respectively.	More extensive exhaled air dispersion and room contamination occurs during application of a jet nebuliser to patients with more severe lung injury. Use of alternative methods to deliver bronchodilators (eg meter-dose inhaler via an aerochamber or a spacer) is advised.
Hui et al 2019 [6]	Exhaled air dispersion during high-flow nasal cannula therapy versus CPAP via different masks	Human patient simulator (HPS) Isolation room with 16 air changes·h−1.	HPS was programmed to represent different severity of lung injury. CPAP was delivered at 5–20 cmH2O via nasal pillows (Respironics Nuance Pro Gel or ResMed Swift FX) or an oronasal mask (ResMed	Exhaled airflow was marked with intrapulmonary smoke for visualisation and revealed by laser light-sheet. Normalised exhaled air concentration was estimated from the light scattered by the smoke	In the normal lung condition, mean ± SD exhaled air dispersion, along the sagittal plane, increased from 186±34 to 264±27 mm and from 207±11 to 332±34 mm when CPAP was increased from 5 to 20 cmH2O via	Exhaled air dispersion during HFNC and CPAP via different interfaces is limited provided there is good mask interface fitting.

			Quattro Air). HFNC, (Model: not reported) humidified to 37°C, was delivered at 10–60 L/min^{-1} to the HPS	particles. Significant exposure was defined when there was ≥20% normalised smoke concentration.	Respironics and ResMed nasal pillows, respectively. Leakage from the oronasal mask was negligible. Mean ± SD exhaled air distances increased from 65±15 to 172±33 mm when HFNC was increased from 10 to 60 L·min^{-1} Air leakage to 620 mm occurred laterally when HFNC and the interface tube became loose.	
Kotoda et al 2020 [7]	The risk of pathogen dispersal during high-flow nasal therapy	Both experiments: HFNC device (AIRVO, Fisher & Healthcare, Auckland, New Zealand), nasal cannulas (Optiflow Nasal Cannula M, Fisher & Healthcare), Human patioen simulator (HPS) (Airway Man, Ambu, Copenhagen, Denmark), water-sensitive paper (AS ONE, Osaka, Japan), fresh yeast (Sacchromyces cerevisiae) Experiment 1: Fluid mimicking nasal mucus and saliva Experiment 2: Water and fresh yeast (location and ventilation: not reported)	Medical training manikin (HPS) operating at 10 min flow rate of 60 L/min. 18 sheets of water-sensitive paper placed at intervals of 30 cm facing the manikin's face. 4 four sheets of paper placed 5 m away in all four directions.	The minimum droplet size detectable by the paper was 50 µm, (the paper could detect the average-sized droplets exhaled during coughing and talking (50–100 µm) in clinical settings). One hour from exposure number of spots on the sheets was enumerated	In the liquid dispersal experiment, water was detected only on the sheet placed in front of the manikin's face (3.7±1.2 spots Colony formation was observed only on the dish that was closest to the manikin's face (2.3±0.5 colonies).	It is likely that high-flow nasal therapy does not increase the potential risk of droplet and contact infection. However, there is a possibility that the device generates smaller particles (aerosol) that may remain in the air and may cause airborne infection rather than droplet infection.

Leonard et al 2020 [8]	Effect of the addition of a surgical mask over the face on the velocity of the gas outflow into the room	In-silico simulation, ANSYS, Inc., Canonsburg, PA, USA	HVNI therapy was modelled from CT-derived architecture of a petite adult female, sinusoidal breathing a 500 ml tidal volume at 32 breaths per minute and a 1:1	A tetrahedral mesh-geometry totaling 6 million elements with 1.1 million resulting polyhedra was used.	The simulated surgical mask during HVNI at 40 L/min-1 captured 83.2% of particles; LFO2 at 6 L·min-1 captured 73.6% of particles.	These preliminary findings suggest the addition of a simple Type-I surgical mask may provide an effective tool to further reduce droplet deposition due to exhaled gas flow, except at mask leaks.
McGrath, O'Sullivan, et al 2019 [9]	Investigation of the Quantity of Exhaled Aerosols Released into the Environment during Nebulisation	Two nebulisers in combination with an open or valved facemask or using a mouthpiece with and without a filter on the exhalation port. Experiment 1: Vibrating mesh (VMN), aerosol chamber (Aerogen Solo/Ultra, Aerogen, Galway, Ireland) with valved facemask, Experiment 2: A jet (JN) (Cirrus 2, Intersurgical, Wokingham, United Kingdom), with open facemask. Laboratory room, the air change rate was 2,70 $1h^{-1}$	A simulated adult breath was used (breath rate 15 BPM, tidal volume 500 mL and inspiratory: expiratory (I:E ratio) 1:1. A nominal dose of 2.5 mL (2.5 mg) albuterol sulphate (Ventolin, 1 mg/mL, GSK, Cork, Ireland) was nebulized in each test run.	The inhaled dose and residual mass were quantified using UV spectrophotometry. Time-varying fugitively-emitted aerosol concentrations and size distributions during nebulisation were recorded using aerodynamic particle sizers at two distances relative to the simulated patient.	Within each nebuliser, the facemask combination had the highest time-averaged fugitively emitted aerosol concentration, and values up to 0.072±0.001 mg m^{-3} were recorded. The placement of a filter on the exhalation port of the mouthpiece yielded the lowest recorded concentrations.	The results highlight the potential secondary inhalation of exhaled aerosols from commercially available nebuliser facemask/mouthpiece combinations.

McGrath, O'Toole, et al 2019 [10]	Investigation of Fugitive Aerosols Released into the Environment during High-Flow Therapy	A nasal cannula (The Optiflow systemAirvo 2, Fisher & Paykel Healthcare, Auckland, New Zealand) was connected to a head model (adult nasal cannula, (P/N: OPT 944) Alternatively, interface was connected to a tracheostomy tub (P/N OPT 970) Laboratory room, the air change rate was approximately 0.65 h-1	HPS (P/N: 900PT552) simulated adult and paediatric breathing profile.	Two aerodynamic particle sizers (APS, model 3321 TSI Inc., St. Paul, MN, USA)) recorded time-series aerosol concentrations and size distributions at a distance of 0.8 m and 2.2 m away from the patient. They continuously measured aerosol mass concentrations and size distributions (0.5 to 20 m) of the airborne concentration in the room.	Quantity and characteristics of the fugitive emissions were influenced by the interface type, patient type and supplemental gas-flow rate. There was a trend in the adult scenarios; as the flow rate increased, the fugitive emissions and the mass median aerodynamic diameter (MMAD) of the aerosol both decreased.	Overall, the results highlight the potential for secondary inhalation of fugitive emissions released during simulated aerosol treatment with concurrent high-flow therapy. The findings will help in developing policy and best practice for risk mitigation from fugitive emissions.

PIF = prolactin-inhibiting factor; **PEEP** = positive end-expiratory pressure; **EPAP** = expiratory positive airway pressure; **HPS** = human-patient simulator; **IPAP** = inspiratory positive airway pressure; **NPPV** = non-invasive positive-pressure ventilation; **SARS** = severe acute respiratory syndrome; **HVNI** = High Flow Therapy, including High Velocity Nasal Insufflation; **APS** = aerodynamic particle sizers

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