Supplementary Document 1 - Assessing the evidence base for medical procedures which may create a higher risk of respiratory infection transmission from patient to healthcare worker

Methods:

A rapid review of evidence from academic databases was conducted. The search strategy was as follows:

1. aerosol generating procedure.tw
2. aerosol generating procedure*.mp
3. (aerosol adj3 procedure).mp
4. (aerosol or airborne).mp
5. Airborne infection.mp
6. Aerosol*.mp
7. Occupational exposure.mp
8. Infectious disease transmission.mp
9. Infection control.mp
10. Infection control, dental.mp
11. exp cross infection/

12. Disease outbreaks.mp
13. Disease transmission.mp
14. 1 or 2 or 3 or 4 or 5 or 6
15. 7 or 8 or 9 or 10 or 11 or 12 or 13
16. 14 and 15
17. limit 16 to English language
18. limit 17 to human
19. limit 18 to humans
20. limit 19 to yr="2000 – Current”

Results incorporated evidence assessed as part of the 2019 Health Protection Scotland NIPCM AGP systematic review. The above search is being repeated and updated on a weekly basis.

Red denotes weak or moderate evidence for increased risk of respiratory infection transmission

Green denotes weak evidence that a procedure is not associated with an increased risk of respiratory infection transmission

Yellow denotes evidence that cannot be used due to limitations or confounding factors

Results				
Procedure: Bronchoscopy	**Evidence of aerosol production studied**		**Evidence of transmission risk studied**	
	Study	**Findings**	**Study**	**Findings**
	Characterization of Aerosols Generated During Patient Care Activities. **Caroline A. O'Neil, Jiayu Li, Anna Leavey, Yang Wang, Matthew Hink, Meghan Wallace, Pratim Biswas, Carey-Ann D. Burnham and Hilary M. Babcock; for the Centers for Disease Control and Prevention Epicenters Program.** **Clinical Infectious Diseases, 2017;65(8):1342–8**	Air samples were taken during patient care activities (including bronchoscopy) carried out on recruited subjects. Each activity was sampled 5 times. Air samples were analysed for particle size to determine whether aerosols were generated and microbiological testing was carried out to detect bacteria in the samples. The authors state that significant aerosol generation was only observed during nebulized medication administration (NMA), both alone and during bronchoscopy. Bronchoscopy without NMA and non-invasive ventilation did not generate significant aerosols. However, no statistical analysis was carried out on these data. Bacteria were isolated from 6 of the 28 baseline samples (21.4%), compared with 14 of 50 procedure samples (28.0%). Again, no statistical	**Aerosol generating procedures (AGP) and risk of transmission of acute respiratory diseases (ARD): A systematic review.** **Tran K, Cimon K, Severn M, et al.** **PloS One 2012; 7**	The review included ten studies (five case-control; five cohort), all of which were graded by the authors as being of very low quality and all of which investigated the protective measures or the risk factors for transmission of SARS from patients to healthcare workers in intensive care or other hospital settings during the 2002-2003 SARS outbreaks. The review found, based on the included studies, that bronchoscopy was not significantly associated with an increased risk of transmission. The findings of the review suggest that some procedures potentially capable of generating aerosols have been associated with increased risk of SARS transmission to healthcare workers, or were a risk factor for transmission, with the most consistent association across multiple studies associated with tracheal intubation.

		analysis was used to compare these figures. Twenty-five samples were collected during procedures involving patients who were on contact precautions for drug-resistant organisms. None of the drug-resistant organisms were recovered from any of these. The study had a small sample size and was missing key statistical analysis information. **This study provides very weak evidence that bronchoscopy is not associated with a significant increase in aerosol generation.**		However, this systematic review included only ten studies, all of which concerned SARS and all of which were assessed as very low quality by the GRADE system. The review authors caution that the findings should not be generalised to all ARIs because the evidence is limited to SARS. The authors note that their review highlights the lack of high quality studies examining the risk of transmission of organisms responsible for ARIs to healthcare workers caring for patients undergoing AGPs, and highlights the lack of precision in the definition for AGPs. **This review provides weak evidence that bronchoscopy is not associated with an increased risk of ARI transmission.**
	Bacteria emitted in ambient air during bronchoscopy—a risk to health care workers? **Genevieve Marchand, Caroline Duchaine, Jacques Lavoie, Marc**	The study assessed microbiological air quality using Andersen impactors (air samplers). Two rooms were sampled during bronchoscopy. 5 bronchoscopies were performed in room A and 10 in room B. All samples were collected at a fixed station located within a radius of 1.5 m from the patient's mouth and the workers'		

	Veillette, Yves Cloutier. **American Journal of Infection Control 44 (2016) 1634-8.**	breathing zone. Sampling continued for 20 minutes at the end of the day. The average concentrations measured in room A varied from 43-100 CFU/m3 air. In room B, the average concentrations were higher, ranging from 40-370 CFU/m3. The concentration of bacteria in the air was significantly higher (p=<0.05) during procedures in both rooms than at the end of the day (20 minutes after last procedure), however, there was no significant difference with the morning background rate. Neither Mycobacterium spp. nor influenza A and B viruses were detected. There was a trend to increasing bacterial contamination during procedures compared to background levels but this was not statistically significant for all testing periods. The small study size may have meant the study was underpowered; in addition, very scant statistical results are given, only p values are provided without confidence intervals etc. Room B appeared to have the greatest increase in microbial		

		contamination of the air during procedures; it is possible that the larger volume and newer construction of room A led to a greater dilution of airborne organisms, however, without detailed patient information it's not possible to know if underlying condition or infection also played a role. **This study provides very weak evidence that bronchoscopy is associated with an increase in airborne microorganisms.**		
	Influenza Aerosols in UK Hospitals during the H1N1 (2009) Pandemic – The Risk of Aerosol Generation during Medical Procedures. **Katy-Anne Thompson, John V. Pappachan, Allan M. Bennett, Himanshu Mittal, Susan Macken, Brian K. Dove, Jonathan S.**	**Air samples taken during Bronchoscopy. The presence and proportion of airborne particles containing influenza RNA in size fractions of >7.3 µm, 4–7.3 µm and 0.86–4µm was compared for samples taken at baseline and those taken during bronchoscopy. 75.1% of the total amount of RNA recovered from all the bronchoscopy samples was collected in the stages <7.3 µm. An analysis of specific procedures found an increased association**		

	Nguyen-Van-Tam, Vicky R. Copley, Sarah O'Brien, Peter Hoffman, Simon Parks, Andrew Bentley, Barbara Isalska, Gail Thomson, on behalf of the EASE Study Consortium. **PLOS ONE February 2013, Volume 8, Issue 2, e56278**	**with aerosol production for bronchoscopy (OR = 43.8(1.06–1809) but this was not statistically significant. The study was likely underpowered to detect a statistically significant difference between the baselines and samples taken during AGPs. The authors acknowledge several other limitations e.g. Baseline samples were taken during activities that did not meet the WHO definition of an AGP; there is a risk that the activities that were being performed were unrecognized AGPs. This study assessed presence of viral RNA only and not live virus and so the viral RNA detected may not be viable. There were in some cases very large variation in the number of airborne particles generated from patient to patient; it is likely that patient specific factors such as stage of infection, age, underlying conditions etc. contribute to the production of aerosols.**		

		This study provides very weak evidence that bronchoscopy is associated with an increase in airborne influenza. It found that 75% of viral RNA (of unknown viability) was recovered from particles smaller than 7.3µm in diameter with 30% being below 4µm, during bronchoscopy. However, it was underpowered and the results were not statistically significant. Whether the findings were significantly different to baseline percentages is not reported.		
	Potential for occupational exposures to pathogens during bronchoscopy procedures, **Zietsman M, Phan LT & Jones RM (2019)** **Journal of Occupational and Environmental**	In this study particles of sizes <10µm and 0.2-1µm were measured using two different sampler devices in the vicinity of the patients' heads during 18 bronchoscopy procedures performed by 7 pulmonologists. Limitations of this study include participant volunteer bias, observed practices being different from in vivo practices, unknown infective status of patients (authors hypothesise that it is unlikely patients had current		

	Hygiene, 16:10, 707-716	respiratory infections), relatively small sample size and that the sampler inlets were not in the breathing zone of the pulmonologists. Results from the 'Sidepak' device which counted particles of 10µm or less may be less relevant as these may contain droplets (≥5µm). Airway suctioning occurred in 17 of the 18 procedures. All but one patient coughed during the procedure. Amount of patient coughing did not vary significantly based on access route eg. mouth or nose. Bronchoscopy procedures were not found to increase the mean number or the mass concentration of respirable particles, but (in five randomly selected procedures) short-duration peak exposures during the procedure were observed which may have infection transmission relevance. The five procedures where particle concentrations were measured over time may hold clinical relevance. One cannot ascertain the biological nature or infectivity of these aerosols and		

		spikes were not found to be aligned with coughing or suctioning events. As the sample size for 'particle concentrations assessed over time' was only 5, this calls into question the scientific validity of these findings. **This study provides weak evidence that aerosol levels may spike during bronchoscopy but very weak evidence that these spikes may be higher than pre-procedural background levels.**		
Assessment of Evidence for Bronchoscopy	O'Neil et al's 2017 study provides very weak evidence to refute that bronchoscopy is associated with a significant increase in airborne microorganisms whereas Marchand et al's 2016 study provides very weak evidence that bronchoscopy is associated with an increase in airborne microorganisms. Thompson et al's 2013 study, which focused on viral aerosols rather than bacterial sampling, provides very weak evidence that bronchoscopy is associated with an increase in airborne influenza but the results were not statistically significant and the study was underpowered. Based on the studies assessed by Tran et al 2012, there is no evidence that bronchoscopy is associated with a significant increased risk of ARI transmission. There is very weak evidence to suggest that bronchoscopy is associated with a significant increase in airborne microorganisms. There is weak evidence to suggest that bronchoscopy is not associated with an increased risk of ARI transmission.			

Procedure: Endoscopy	Evidence of aerosol production studied		Evidence of transmission risk studied	
	Study	**Findings**	**Study**	**Findings**
			Aerosol generating procedures (AGP) and risk of transmission of acute respiratory diseases (ARD): A systematic review. **Tran K, Cimon K, Severn M, et al.** **PloS One 2012; 7.**	**Study selection criteria for this review included consideration of "upper GI endoscopy" but no associated studies appear to have been found or deemed suitable for inclusion, by the authors.**
Assessment of Evidence for Endoscopy	There is no evidence to suggest that upper or lower GI endoscopy procedures specifically have been associated with an increased ARI transmission risk to healthcare workers, however, other associated procedures such as airway suctioning, should be considered individually.			

Procedure: Airway suctioning	Evidence of aerosol production studied		Evidence of transmission risk studied	
	Study	**Findings**	**Study**	**Findings**
	Influenza Aerosols in UK Hospitals during the H1N1 (2009) Pandemic – The Risk of Aerosol Generation during Medical Procedures. **Katy-Anne Thompson, John V. Pappachan, Allan M. Bennett, Himanshu Mittal, Susan Macken, Brian K. Dove, Jonathan S. Nguyen-Van-Tam, Vicky R. Copley, Sarah O'Brien, Peter Hoffman, Simon Parks, Andrew Bentley, Barbara Isalska, Gail Thomson, on behalf**	Air samples taken during respiratory and airway suctioning (including tracheostomy care and open suctioning with invasive ventilation). The study does not specify whether this includes procedures which included oral suctioning only. The presence and proportion of airborne particles containing influenza RNA in size fractions of >7.3 µm, 4–7.3 µm and 0.86–4µm was compared for samples taken at baseline and those taken during respiratory and airway suctioning. 77.6% was in the <7.3 µm size range with 48% in the 0.86-4µm size range. Analysis of respiratory and airway suctioning found an increased association with aerosol production for respiratory/airway suctioning (OR = 4.11 (0.50–34.0) but this was not statistically significant.	**Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.** **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797**	The review included ten studies (five case-control; five cohort), all of which were graded by the authors as being of very low quality and all of which investigated the protective measures or the risk factors for transmission of SARS from patients to healthcare workers in intensive care or other hospital settings during the 2002-2003 SARS outbreaks. The review found, based on one case-control study, that suctioning of body fluids was not significantly associated with an increased risk of transmission 1.0 (0.4, 2.8). The study used does not specify whether this was exclusively airway suctioning. The authors suggest, however, that based on two cohort studies, suctioning before intubation and suctioning after intubation might be associated with an increased risk of transmission, but the odds ratios were not statistically significant.

	of the EASE Study Consortium. **PLOS ONE February 2013, Volume 8, Issue 2, e56278**	The study was likely underpowered to detect a statistically significant difference between the baselines and samples taken during AGPs. The authors acknowledge several other limitations e.g. Baseline samples were taken during activities that did not meet the WHO definition of an AGP; there is a risk that the activities that were being performed were unrecognized AGPs. This study assessed presence of viral RNA only and not live virus and so the viral RNA detected may not be viable. There were in some cases very large variation in the number of airborne particles generated from patient to patient; it is likely that patient specific factors such as stage of infection, age, underlying conditions etc. contribute to the production of aerosols. **This study provides very weak evidence that respiratory/airway suctioning is associated with an increase in airborne influenza, but it was underpowered and the results were not statistically**		The findings of the review suggest that some procedures that are potentially capable of generating aerosols have been associated with increased risk of SARS transmission to healthcare workers, or were a risk factor for transmission, with the most consistent association across multiple studies associated with tracheal intubation. This systematic review included only ten studies, all of which concerned SARS and all of which were assessed as very low quality by the GRADE system. The review authors caution that the findings should not be generalised to all ARIs because the evidence is limited to SARS. The authors note that their review highlights the lack of high quality studies examining the risk of transmission of organisms responsible for ARIs to healthcare workers caring for patients undergoing AGPs, and highlights the lack of precision in the definition for AGPs. **This review provides weak evidence that suctioning of body fluids is not associated with an increased risk of ARI transmission**

		significant. It showed that 78% of viral RNA (of unknown viability) was recovered from particles smaller than 7.3µm in diameter with 48% being 0.86-4µm, however it is not reported as to whether this was statistically significantly different to baseline percentages.		**This review provides very weak evidence that suctioning before intubation and suctioning after intubation is not associated with a significantly increased risk of ARI transmission.**
	Aerosol Distribution During Open Suctioning and Long-Term Surveillance of Air Quality in a Respiratory Care Center Within a Medical Center. **Fen-Fang Chung, Hui-Ling Lin, Hsueh-Erh Liu, Angela Shin-Yu Lien, Hsiu-Feng Hsiao, Lan-Ti Chou, and Gwo-Hwa Wan.**	Open air suctioning of ventilated patients. Air samples were taken before, during and after open suctioning of ventilated patients, these samples were assessed for particle size (≤10µm, ≤2.5µm and ≤1µm) and presence of microbes. Continuous air sampling was carried out for 3-min before the procedure, 1.5-min sampling during the procedure and 3-min sampling 5 min after the procedure. The mean concentrations of airborne particles were 14.88 µg/m3 for PM10, 3.78 µg/m3 for PM2.5, and 1.84 µg/m3 for PM1 before open suctioning, versus 21.01 µg/m3, 6.54 µg/m3, and 3.75 µg/m3 during the procedure, and	**Aerosol transmission of severe fever with thrombocytopenia syndrome virus during resuscitation.** **Jaeyoung Moon, Hyeokjin Lee, Ji Hoon Jeon, Yejin Kwon, Hojin Kim, Eun Byeol Wang, Choong Won Seo, Sul A. Sung, Su-Hyun Kim, Hyeri Seok, Won Suk Choi, WooYoung Choi and Dae Won Park.**	This case report describes the transmission of severe fever with thrombocytopenia syndrome virus (SFTFV) to a HCW during endotracheal intubation of an infected patient. In total 14 HCWs were identified as having contact with the patient. The investigation collected data from staff including demographic data, clinical symptoms, signs of SFTS, history of tick bites, animal contacts, routes of possible exposure to risk factors, the use of protective devices, and protective behaviours. Airborne precautions were not put in place before the diagnosis of SFTSV), it is unclear if they were subsequently implemented. Droplet precautions (surgical mask) were used by 10 of the 14 staff, of the four who did not wear masks three were nurses who performed suctioning and one was a

	RESPIRATORY CARE, JANUARY 2015, VOL 60, NO 1	13.48 µg/m3, 2.12 µg/m3, and 1.01 µg/m3 afterwards. The changes in PMs before, during, and after suctioning were significant (p=0.01). To assess the influence of the open suctioning procedure, the air bacterial concentration (290.45 CFU/m3) during the procedure significantly exceeded that before (191.52 CFU/m3, p=0.02) and after (187.46 CFU/m3, p=0.02). This study provides no patient data e.g. the reason for being admitted to the respiratory ward, presence of infection etc. it is also provides no data on the number of patients included or the number of samples taken. Therefore the statistical analyses cannot be interrogated and it is difficult to extrapolate these findings to infection risk with confidence. **The study provides weak evidence that during open suctioning of ventilated patients there is a significant increase in the concentration of airborne particles,**	**Infection Control & Hospital Epidemiology (2019), 40, 238–241**	mortuary beautician. All staff with the exception of the beautician wore gloves. The mortuary beautician was considered a suspected case on the basis of fever and increased serum IgG but had a negative RT-PCR result. Transmission of SFTVS was confirmed (clinical symptoms and RT-PCR) in one doctor who performed endotracheal intubation on the patient, it was noted that frequent suctioning of the patient was required due to naso-oral bleeding. The study claims transmission to two HCWs one confirmed (carried out endotracheal intubation with droplet precautions) and one suspected (mortuary beautician who had contact with the patient without adequate contact or droplet precautions in place). This assessment only considers the transmission to the confirmed case as evidence of aerosol transmission. Findings from this case should be extrapolated with caution as SFTVS is a specific virus that may not replicate the transmission modalities of other pathogens.

		including both small droplets of around 5-10µm and aerosols of between 1-5µm and an increased concentration of airborne bacteria although it is unclear if this is linked to the suctioning process itself or disconnection of the ventilator.		**The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the high risk elements of the process.**
			Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. **Hae-Sung Nam, Mi-Yeon Yeon, Jung Wan Park, Jee-Young Hong, Ji Woong Son.** **Epidemiology and Health. 2017 Volume: 39**	This report describes the investigation of a case of MERS-CoV transmitted to a HCW during a large hospital outbreak in South Korea in 2015. The HCW was a nurse who performed CPR on an infected patient for around 1 hour. Haemoptysis was continuously observed whilst intubation and suctioning of the airways was performed. CPR was performed in a negative pressure isolation room, a large amount of body fluid was splashed during the procedure and the nurse remained in the room for around 2-3 hours after performing CPR to clean the room. After recovery the nurse noted that her goggles were heavy and had slid down along with her surgical mask while performing CPR, in addition CCTV revealed she had touched the masks and goggles with contaminated gloves and had wiped away

				sweat. Findings from this case should be extrapolated with caution as MERS-CoV is a specific virus that may not replicate the transmission modalities of other pathogens. **The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the high risk elements of the process.**
			Probable Crimean-Congo hemorrhagic fever virus transmission occurred after aerosol-generating medical procedures in Russia: nosocomial cluster **Natalia Yurievna Pshenichnaya, Svetlana Alexeevna Nenadskaya.** **International Journal of Infectious**	This report describes the transmission of CCHF to 8 HCWs who cared for an infected patient (one doctor was also involved in the care of two other infected patients). As part of her care the patient was ventilated in a neutral pressure side room. All staff who has contact with the patient wore gloves, surgical masks and gowns. Six HCWs could potentially have had contact with the patient's blood or body fluids or could have used their PPE inappropriately, however, two staff had no direct or indirect contact with body or fluids of the patient.

			Diseases 33 (2015) 120–122	This study provides weak evidence that airborne transmission to at least two of the infected HCWs occurred through being in the room when high risk procedures were being conducted. These staff were present in the room during these procedures but had no direct contact with the patient, presumably they had some minimal contact with the patient's environment e.g. door handles, however this is not highlighted as a risk by the authors. Findings from this case should be extrapolated with caution as CCHF is a specific virus that may not replicate the transmission modalities of other pathogens. **Although airway suctioning may have been performed e.g. as part of intubation. This study cannot be used to provide evidence for the ARI transmission risk associated with airway suctioning as it is not specifically mentioned.**

Defining airway suctioning	<u>Study descriptions of airway suctioning</u> Thompson et al. sampled air during procedures categorised as AGPs by the World Health Organisation in 2009, this included, as the authors describe, “respiratory and airway suctioning”. On examination of the WHO 2009 interim guidance the following wording was used: “aspiration or open suctioning of the respiratory tract”. This study provided very weak evidence that respiratory/airway suctioning is associated with an increase in airborne influenza. Tran et al. 2012 refer to ‘airway suctioning’ and to 3 suctioning processes in their systematic review: suctioning before intubation, suctioning after intubation and body fluid suctioning with reference to 3 papers. These are described separately below. In Tran et al’s 2012 review: • Body fluid suctioning is referenced in relation to Teleman et al’s 2004 paper where the authors refer to the HCW risk factor as ‘performed suction of body fluids’ but do not indicate the type of fluids/location of suctioning. Suctioning of body fluids was not significantly associated with an increased risk of transmission 1.0 (0.4, 2.8). • Suctioning before intubation is referenced in relation to Loeb et al’s 2004 paper and Raboud et al’s 2010 paper. In Loeb et al’s paper authors refer to ‘suctioning of endotracheal tubes’ and ‘suctioning before intubation’ but give no further explanations. In Raboud et al’s paper, authors refer to ‘suctioning’ which they classify as an ‘airway management procedure’ and ‘suctioning before intubation’. According to Tran et al, suctioning before intubation was not significantly associated with an increased risk of transmission 3.5 (0.5, 24.6). • Suctioning after intubation is referenced in relation to Loeb et al’s 2004 paper and Raboud et al’s 2010 paper. In Loeb et al’s paper authors refer to ‘suctioning of endotracheal tubes’ and ‘suctioning after intubation’ but give no further explanations. In Raboud et al’s paper, authors refer to ‘suctioning’ which they classify as an ‘airway management procedure’ and ‘suctioning after intubation’. According to Tran et al, suctioning after intubation was not associated with an increased risk of transmission 1.3 (0.5, 3.4).

	Chung et al 2015 conducted air sampling before, during and after "open suctioning in mechanically ventilated patients". This study provided weak evidence that during open suctioning there is a significant increase in the concentration of airborne particles, including both small droplets of around 5-10µm and aerosols of between 1-5µm and an increased concentration of airborne bacteria. Chung et al 2015 provide an explanation as to why open suctioning may increase levels of airborne microorganisms: *"Before performing open suctioning, the endotracheal tube must be disconnected from a ventilator circuit. A few phenomena are observable while the endotracheal tube of the patient is discontinued from a mechanical ventilator; 1) the mechanical ventilator provides a much higher flow to compensate for the low pressure in the ventilator circuit, and the condensates in the ventilator circuit may then be aerosolized from the forceful gas flow. This results in contamination of the air in the room.*"
Assessment of evidence for airway suctioning	**There is weak evidence to suggest that suctioning the airway of ventilated patients leads to a significant increase in airborne bacterial contamination and an increase in the production of small droplets and aerosols.** **There is very weak evidence that suctioning of the airway does not create an increased risk of ARI transmission and weak evidence that 'suctioning of body fluids' is not significantly associated with an increased risk of ARI transmission**

Procedure: High flow nasal oxygen	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	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, G.M. Joynt, C.D. Gomersall, W.T. Wong, A. Lee, L. Ling, P.K.S. Chan, P.C.W. Lui, P.C.Y. Tsoi, C.M. Ling, M. Hui.**	A small, randomised cross-over trial to compare the bacterial environmental contamination created through HNFO therapy versus conventional facemask administered oxygen therapy. The authors found no statistically significant difference in Gram negative or total bacterial counts using an air sampler or settle plates placed at 0.4 and 1.5m from the patient, in isolation rooms with 6 or 12 air changes per hour. This study had a number of limitations which included its focus on bacterial rather than viral contamination, the small number of participants (with the authors acknowledging that the study was underpowered), the inability to definitively link bacteria on settle plates to index patients, a lack of information given on the flow rate of oxygen administrated via facemask and an inability to establish if bacteria		

	Journal of Hospital Infection 101 (2019) 84e87.	were pathogenic or would have led to infection transmission. **This study provides very weak evidence to suggest that HFNO does not generate a significantly different level of airborne bacterial contamination than conventional oxygen therapy delivered via a face mask. As the study analysed bacteria rather than viruses, the evidence has been assigned as inconclusive.**		
	Nasal high-flow therapy and dispersion of nasal aerosols in an experimental setting. **Roberts S, Kabaliuk N, Spence C, O'Donnell J, Zulkhairi Abidin Z, Dougherty R, Roberts S, Jiang Y and Jermy Mc**	An experimental study which compared the exhaled air dispersion distances created in the lateral and median sagittal plane from a patient simulator sitting at 45° in a negative pressure isolation room with 16 air changes per hour using either high flow nasal cannula oxygen therapy or CPAP therapy. Air was marked with oil based smoke particles and a laser smoke visualisation method was used. Exposure zones were arbitrarily classified as those areas with equal to or greater than 20% smoke concentration. Although		

	Journal of Critical Care. Vol 30 (4) p842.2015	measurements were taken under differing flow rates for both procedures, the differences in dispersion distances between HFNO and CPAP were never directly compared, with no presentation of statistical difference. Greatest distances were observed for both procedures along the sagittal plane with the simulator set to replicate 'normal' lung function and oxygen set to the highest flow rates (60L/min for HFNO and 20cmH2O for CPAP). Greatest distances created were 172+/-33mm for HFNC compared to 332+/-34mm for CPAP using nasal pillows. This study had many limitations which included its experimental nature, the high air change rates and equipment used which may not replicate conventional clinical scenarios within the UK. **This study provides low quality evidence to suggest that aerosols created during CPAP may disperse over greater distances (upwards from the source) compared to those created via HFNO but one**		

		cannot be certain that it is statistically significantly less or clinically relevant due to limitations of the study and a failure to directly compare the systems with one another. **Presentation of lateral distances may be more clinically relevant based on proximity/location of healthcare workers. Interestingly smoke dispersal was not significant along the lateral plane for either pieces of equipment, an exception to this finding was noted, however, when the HFNO nasal cannula/tube interface was loose and lateral smoke distances of 620mm were recorded.**		
Assessment of evidence for high flow nasal oxygen	**There is weak evidence to suggest that HFNO does not create greater levels of airborne bacterial contamination than conventional oxygen therapy delivered via mask or create aerosols which travel greater distances than non-invasive CPAP ventilation.**			

Procedure: Dental procedures	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Aerial dispersal of blood-contaminated aerosols during dental procedures. **H. Yamada, K. Ishihama, K. Yasuda, Y, Hasumi-Nakayama, S. Shimoji, K. Furusawa.** **Quintessence International 42(5), 2011.**	Third-molar surgery, full-crown preparation, inlay cavity preparation and scaling with an ultrasonic device were performed. Class 1 cavity preparation was also conducted which does not involve blood. An extraoral evacuator was set up with test filters able to detect blood, it was placed at 50cm and 100cm behind the patient while the following procedures were carried out. No blood was detected during the control procedure (n=19). At 50cm behind the patients' head the proportion of positive test was 92% (12/13) for 3rd molar extraction, 70% (21/30) for full-crown preparation, 35% (9/26) for inlay cavity preparation and 33% (11/33) for ultrasonic scaling. At 100cm behind the patients' head the proportion of positive test was 90% (35/39) for 3rd molar extraction,		

		48% (15/31 for full-crown preparation, 29% (6/21) for inlay cavity preparation and 12% (4/33) for ultrasonic scaling. There was trend towards a reduced number of positives at 100cm compared to 50cm but this was not significant except for ultrasonic scaling (p=0.0398), no confidence intervals are provided for this p value. This study provides evidence that dental procedures using high-speed instruments can result in blood spread up to 100cm around the patient and into the breathing zone of the dental staff. Since the samples were taken within the range of 1 metre from the patients and the air sampler was not designed to fraction particles into smaller sizes it is not possible to say that the blood detected was in aerosols rather than larger droplet which would settle out fairly quickly. **This study provides clear evidence of dissemination of blood within the operating area of the dentist during a range of procedures. Whether these blood particles would be respirable as an aerosol**		

		or result in infection is unknown. The relevance of these findings for respiratory pathogens is likely to be insignificant.		
	Bacterial aerosols in dental practice - a potential hospital infection problem? **R. Rautemaa, A. Nordberg, K. Wuolijoki-Saaristo, J.H. Meurman.** **Journal of Hospital Infection (2006) 64, 76e81.**	72 samples across 6 rooms were collected where procedures involving high-speed and ultrasonic instruments were used. 24 samples across 4 rooms were collected where procedures not involving high-speed and ultrasonic instruments were performed. 3 rooms were also sampled where no procedures were performed; the number of samples is not specified. Bacterial contamination in procedure rooms was assessed using settle plates. Settle plates placed around the room in pairs at 0.5 to 2 meters from the patient were used to assess room contamination following procedures, swab samples were also taken from surfaces around the room and tested for microbial contamination. The result were expressed as colony forming units		

		(CFU)/m2. During procedures using high-speed and ultrasonic instruments the mean density of aerobic oral bacteria was 823 CFU/m2/h at <1 m distance from the patient and 1120 CFU/m2/h at distances> 1.5 m from the patient. During periodontal and orthodontic treatment the mean density was 598 CFU/m2/h. The difference between the two groups was statistically significant (P<0.001). Rooms at rest had a mean contamination rate of 35 CFU/m2/h. The settle plates were placed within the range of droplets but the difference between paired plates at 1.5 and 3 hours suggests that airborne particles were still present and continuing to settle in this time period, the difference however was not significant and must be interpreted cautiously. In addition, paired plates do not appear to have been used in the control room, or at least the results have not been presented and so it's not possible to say that significant contamination wouldn't have been present in both the		

		intervention and control rooms compared to the at rest rooms. **This study provides moderate evidence that procedures involving high-speed and ultrasonic dental instruments cause significantly greater environmental contamination than procedures that don't. The study provides weak evidence that these procedures generate small inhalable aerosols.** **Environmental contamination was evident in both procedural rooms. It is unclear as to the clinical/infection control relevance of their being less contamination associated with the high speed device procedures.**		
	Aerosol, a health hazard during ultrasonic scaling: A clinico-microbiological study. **Singh A, Shiva Manjunath R G,**	This study evaluated environmental bacterial contamination produced during ultrasonic scaling using microbiological analyses (bacterial counts on agar plates, 1x placed in middle of room; 1x placed 40cm from working area near patients chest) and found that the results for bacterial counts were highly significant when		

	Singla D, Bhattacharya HS, Sarkar A, Chandra N. **Indian J Dent Res 2016;27:160-2**	compared before and during the treatment. **This study provides weak evidence that high levels of environmental bacterial contamination are created following ultrasonic scaling.**		
	Dissemination of aerosol and splatter during ultrasonic scaling: a pilot study. **Veena HR, Mahantesha S, Joseph PA, Patil SR, Patil SH.** **Journal of infection and public health. 2015 May 1;8(3):260-5.**	This study aimed to evaluate contamination distance (up to 5ft) and duration of 'aerosol' produced during ultrasonic scaling. Contamination was found up to 4ft from the 'patient' and the 'aerosol' cloud remained in the operatory air from 0-30 min after the procedure was completed. **This in vitro study provides very weak evidence that aerosols are produced following ultrasonic scaling.**		
	Microbial aerosols in general dental practice. **Bennett AM, Fulford MR, Walker JT,**	In this study the concentrations of bacterial aerosols in general dental practices were measured using three different samplers:		

	Bradshaw DJ, Martin MV, Marsh PD. **British dental journal. 2000 Dec;189(12):664-7.**	1) at bench height within 1m of the patients' mouths. The sampler was used continuously, for 2-minute periods, during morning treatment sessions (9.30am-1pm. Background samples taken for 5-minute periods outside the treatment room every 30 minutes. 2) Particle size established through a different type of sampler placed at foot of dental chair within 2m of patients mouth during procedures that were considered to be aerosol generating for 5 minutes. 3) Sampler clipped to chest of dentist with samples tested for presence of blood and micro-organisms. Peaks in concentrations of bacteria were observed (defined as at least a threefold increase from background levels) in 6/12 treatment sessions. 11 peaks were found during 23 ultrasonic/sonic scaling procedures		

		compared to 4 in 36 drilling episodes (Chi2 test statistic 9.98, P = 0.001578)". Therefore, it seems that peaks were more often associated with scaling but overall less than 50% of scaling procedures gave rise to peaks, implying additional factors may be involved. *"Presumptive oral streptococci (EPS-producers) made up over 50% of the colonies on TYC plates during peaks suggesting that some dental procedures gave an increased production of airborne orally-derived micro-organisms"* however, one cannot ascertain the specific procedures and the authors do appear to report on particle sizes. Blood was not detected in any of the personal air samples. No peaks were found on either visit to two of the surgeries which leads one to consider other influential factors (different procedures performed in these settings?)		

		12 treatment sessions represent a small sample size. Background samples were taken over 5 minute periods instead of the 2 minute periods used during treatment sessions. Authors frequently refer to 'aerosol peaks' and 'aerosol production' but do not appear to provide results beyond an increase in bacterial air contamination and with no indication of particle sizes. Authors do not appear to define whether drilling episodes refers to high speed and/or slow speed drilling. Airborne bacterial contamination is an indirect measure of infection. They argue that there might be a small risk to dentists and correct PPE should be worn. **This study suggests that peaks in bacterial airborne contamination are more likely to occur during sonic and ultrasonic scaling but overall due to this study's limited presentation of data, its findings are deemed to be inconclusive.**		

Assessment of evidence for dental procedures:	**There is moderate evidence that ultrasonic scaling and drilling produces respirable aerosols.** **There is very weak/inconclusive evidence to support the creation of infectious aerosols during dental procedures**

Procedure: Chest compressions/de fibrillation	**Evidence of aerosol production studied**		**Evidence of transmission risk studied**	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
			Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. **Hae-Sung Nam, Mi-Yeon Yeon, Jung Wan Park, Jee-Young Hong, Ji Woong Son.**	This report describes the investigation of a case of MERS-CoV transmitted to a HCW during a large hospital outbreak in South Korea in 2015. The HCW was a nurse who performed CPR on an infected patient for around 1 hour. Haemoptysis was continuously observed whilst intubation and suctioning of the airways was performed. CPR was performed in a negative pressure isolation room, a large amount of body fluid was splashed during the procedure and the nurse remained in the room for around 2-3 hours after performing CPR to clean the room. After

			Epidemiology and Health. 2017 Volume: 39	recovery the nurse noted that her goggles were heavy and had slid down along with her surgical mask while performing CPR, in addition CCTV revealed she had touched the masks and goggles with contaminated gloves and had wiped away sweat. Findings from this case should be extrapolated with caution as MERS-CoV is a specific virus that may not replicate the transmission modalities of other pathogens. **The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements.**
			Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.	This review found that chest compressions and defibrillation were not significantly associated with an increased risk of SARS infection. Pooled estimates suggested that chest compressions might be associated with an increased risk of transmission, but the odds ratios were not statistically significant.

			Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly. **PLOs One, 2012, 7(4), e35797.**	Chest compressions from one case control study (Liu et al 2009) were claimed to be a risk factor for transmission but it could not be separated from intubation which was found to be more risky. Furthermore, this finding was in contradiction to two cohort studies, which did not find a significantly increased risk of transmission (Loeb et al 2004; Raboud et al 2010)." **This review provides weak evidence that chest compressions are not associated with an increased risk of ARI transmission.**
Assessment of evidence for chest compressions / defibrillation	**There is very weak evidence that chest compressions and/or defibrillation do not create an increased risk of ARI transmission.**			

Procedure: Surgery and post-mortem procedures	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Aerosol production during autopsies: The risk of sawing in bone. **Jip M.E. Pluim, Lucas Jimenez-Boua, Reza R.R. Gerretsen, Arjo J. Loeve.** **Forensic Science International 289 (2018) 260–267**	The number of aerosol particles present in the air during bone sawing was measured using a Fluke 985 particle counter. The greatest number of aerosol particles was consistently produced in the condition with the highest tested frequency (250 Hz) and the lowest tested contact load (3 kg). The lowest number of aerosol particles was consistently produced in the condition with the lowest tested frequency (150 Hz) and the highest tested contact load (5 kg). Two-way ANOVA showed significant effects of frequency and of contact load on the number of aerosols particles for particle sizes 0.3, 0.5, 1.0 and 2.0 µm ($p < 0.001$). **This study provides moderate evidence that sawing of bone e.g. during autopsy using an oscillating**		

		saw can produce aerosols within the respirable range.		
	Contamination during removal of cement in revision hip arthroplasty. A CADAVER STUDY USING ULTRASOUND AND HIGH-SPEED CUTTERS. **M. Nogler, C. Lass-Flörl, C. Wimmer, E. Mayr, C. Bach, M. Ogon.** **J Bone Joint Surg [Br] 2003;85-B:436-9.**	Cemented arthroplasty was performed on the left hip of a male human cadaver, the cement was then removed using a high-speed cutting device with a 6 mm ball cutter, blood flow was simulated using blood artificially contaminated with Staphylococcus aureus. CFU/metre of S. aureus were detect using culture media plates placed at every metre in the 6x8 metre room (48 plates). The dishes were opened immediately before starting to remove the cement and closed five minutes after completion of the test in order to allow for complete settling of the aerosol. Total exposure time of plates was 40 minutes. The level of contamination was significantly higher using the high speed cutter compared to the ultrasound device, no sampling was taken before either procedure though so it is unknown if the ultrasound device also led to increased airborne		

		room contamination compared to background levels. The study does not summarise the results or provide statistical analysis for the reader and so it is not possible to assess the validity of their conclusions using statistics. No sampling was performed before either procedure so no baseline measurement available for comparison. **This study provides moderate evidence of significant and widespread contamination of the theatre via the airborne route using a high speed cutter compared to an ultrasound device.**		
	Environmental and Body Contamination Through Aerosols Produced by High-Speed Cutters in Lumbar Spine Surgery. **Michael Nogler, Cornelia Lass-Florl**,	Laminectomies at points L2-L4 were performed on a male cadaver using a high-speed cutting device with a 6 mm ball cutter. The irrigation system of the device used saline contaminated with Staphylococcus aureus. Airborne dissemination was measured in CFU/metre of S. aureus by using culture media plates placed at every metre in the 5x7 metre room (48		

	Michael Ogon, Eckart Mayr, Christian Bach and Cornelius Wimmer. **SPINE Volume 26, Number 19, pp 2156–2159.**	plates). Surveillance cultures of bodies and faces were taken from the surgeon, the assistant, the scrub nurse, the anesthesiologist, and the head of the cadaver. All Petri dishes in the area of 5 by 7 m showed growth of S. aureus (range 8 to >100 CFU per plate). Surveillance cultures showed contamination of the faces and bodies of everyone present during the surgery, the surgeon and the surgical assistant being the most severely contaminated. The anesthesiologist and the head of the cadaver also showed contamination with S. aureus. The study is very small and experimental and uses an artificial source of 'infection' therefore it would be beneficial to repeat these measures using real patients. Unfortunately, baseline levels were not carried out however one can assume baseline levels of S. aureus would be close to 0 on sterile materials such as sterile drape and sterile PPE.		

		The study provides moderate evidence of aerosol generation during procedures using high-speed cutting devices.		
	Aerosols produced by high-speed cutters in cervical spine surgery: extent of environmental contamination. **Michael Nogler, Cornelia Lass-Flörl, Cornelius Wimmer, Christian Bach, Christine Kaufmann, Michael Ogon.** **Eur Spine J (2001) 10 :274–277, DOI 10.1007/s005860100310**	Airborne dissemination was measured in CFU/metre of S. aureus by using culture media plates placed at every metre in the 5x7 metre room (35 plates). Surveillance cultures of bodies and faces were taken from the surgeon, the assistant, the scrub nurse, the anesthesiologist, and the head of the cadaver. For air sampling, all Petri dishes in the area of 5 by 7 m showed growth of S. aureus (range 10 to >100 CFU per plate). Surveillance cultures showed contamination of the faces and bodies of everyone present during the surgery, the surgeon and the anaesthesiologist being the most severely contaminated. The study is very small and experimental and uses an artificial source of ‘infection’ therefore it would be beneficial to repeat the study using real patients.		

		Unfortunately, baseline levels were not carried out however one can assume baseline levels of S. aureus would be close to 0 on sterile materials such as sterile drape and sterile PPE **The study provides moderate evidence of aerosol generation during procedures using high-speed cutting devices.**		
Assessment of evidence for surgery and post-mortem procedures	**There is moderate evidence that the use of high speed devices in surgical and post-mortem procedures causes aerosol generation with widespread contamination of the environment.**			

Procedure: Tracheostomy	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
			Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review. **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	The review included ten studies (five case-control; five cohort), all of which investigated the protective measures or the risk factors for transmission of SARS from patients to healthcare workers in intensive care or other hospital settings during the 2002-2003 SARS outbreaks. The review found, based on one case-control study, that the performing tracheotomy created an increased risk of SARS transmission: tracheotomy (OR 4.2, 95% CI 1.5-11.5. **This review provides weak evidence that performing a tracheostomy is associated with a higher risk of ARI transmission.**
Assessment of evidence for tracheostomy	**There is weak evidence that performing a tracheotomy creates an increased risk of ARI transmission**			

Procedure: High Frequency Oscillating Ventilation	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
			Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review. **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	Systematic review of 10 studies, all of which were considered very low quality evidence on assessment with the GRADE system. A single cohort study was identified which assessed HFOV. This procedure was not found to be a significant risk factor in transmission of SARS to HCWs (OR 0.7; 95% CI 0.5, 5.5). This study provides weak evidence that HFOV does not create an increased risk for transmission of SARS via aerosols to HCWs.
			Transmission of severe acute respiratory syndrome during	Retrospective cohort analysis to determine whether specific ventilatory strategies were associated with an increased risk of transmission of SARS to

			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.** **American Journal of Respiratory and Critical Care Medicine. 169, 11 (2004).**	healthcare workers. There was no significant increase in risk of transmission to nurses caring for SARS patients receiving HFOV (RR, 0.74; 95% CI = 0.11 to 4.92; p = 0.6). This well executed observational, retrospective study is considered to be moderate evidence on the risk of transmission of SARS to HCWs. **This study provides moderate evidence that High-Frequency Oscillating Ventilation does not create an increased risk for transmission of SARS via aerosols to HCWs.**
Assessment of evidence for high frequency oscillating ventilation	**From the two studies identified, there is weak to moderate evidence provided that High-Frequency Oscillating Ventilation does not create an increased risk for aerosol ARI transmission. A single, low quality, cohort study identified by Tran et al found that there was no significant risk of transmission of SARS to HCWs during HFOV. This is strengthened by the findings of Fowler et al, which agree that this is not a procedure which creates a significant risk of ARI transmission.** **There is weak to moderate evidence that high frequency oscillating ventilation is not associated with an increased risk of ARI transmission to HCWs.**			

Procedure: Non-invasive ventilation	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Characterization of Aerosols Generated During Patient Care Activities. **Caroline A. O'Neil, Jiayu Li, Anna Leavey, Yang Wang, Matthew Hink, Meghan Wallace, Pratim Biswas, Carey-Ann D. Burnham and Hilary M. Babcock; for the Centers for Disease Control and Prevention Epicenters Program.** **Clinical Infectious Diseases, 2017;65(8):1342–8**	In this study, air samples were collected during patient care activities, with each activity being sampled 5 times. Baseline samples were not collected for particle number and mass concentrations for non-invasive ventilation, and so values for these measurements were not given for this procedure. It was concluded by authors that there was no significant aerosol production during non-invasive ventilation in comparison to the baseline measurements. However, without a baseline measurement for this specific procedure it is unclear how the authors reached this conclusion. Due to this lack of data, this evidence would be considered very weak.	**Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.** **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	Systematic review of 10 studies, all of which were considered very low quality evidence on assessment with the GRADE system. Non-invasive ventilation was covered by 2 cohort studies which found an associated risk with transmission of SARS to HCWs. OR 3.1; 95% CI 1.4, 6.8 (pooled). Additionally, a single cohort study investigated the transmission risk when manipulating a BiPAP mask. No significant association was found in the risk of SARS transmission (OR 6.2; 95% CI 2.2, 18.1). Tran et al conclude that the transmission risk posed by non-invasive ventilation is significant, while that of manipulating a BiPAP mask is not.

		This study provides very weak evidence that non-invasive ventilation is not an aerosol generating procedure		**This study provides weak evidence that NIV creates an increased risk of transmission,** **It also provides weak evidence that manipulating a BiPAP mask does not increase infection transmission**
	Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebulizer treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. **AK Simonds, A Hanak, M Chatwin, MJ Morrell, A Hall, KH Parker, JH Siggers, RJ Dickson.** **Health Technology Assessment 2010;**	In this non-randomised control trial, airborne particle production was assessed during a variety of procedures using an optical particle sizer. Samples were collected at two positions during procedures; adjacent to the subject's mouth (D1), and 1 metre from the subject to represent the typical placement of a healthcare worker during the procedure (D2). 3 participant groups were used during the course of this study; normal controls, subjects with coryzal symptoms, and adult patients with chronic lung disease who were admitted to hospital with an infective exacerbation of their underlying condition NIV using a vented mask resulted in increased droplet production (over 10µm) at D1 in the coryzal (p=0.044)	**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.** **American Journal of Respiratory and Critical Care**	Retrospective cohort analysis to determine whether specific ventilatory strategies were associated with an increased risk of transmission of SARS to healthcare workers. It was found that nurses caring for patients receiving non-invasive positive pressure ventilation were more likely to develop SARS. However, this was not statistically significant (RR, 2.33; 95% CI = 0.25 to 21.76; p = 0.5). **This study provides very weak evidence that non-invasive ventilation is associated with an increased risk for transmission risk of SARS to HCWs.**

	vol. 14: No. 46, 131-172.	and patient groups (p=0.042), at D2 production of all sizes of droplets increased in the coryzal group. This difference was reversed when NIV was performed using a modified NIV circuit with an exhalation filter. These results provide some evidence that non-invasive ventilation is not an aerosol generating procedure. By directly measuring droplet size rather than rate of infection in HCWs as some other studies it avoids confounding due to variation in compliance with infection control procedures. Due to this the evidence can be considered moderate/weak. **This study provides weak to moderate evidence that non-invasive ventilation is not an aerosol generating procedure.**	**Medicine. 169, 11 (2004).**	
			Why Did Outbreaks of Severe Acute Respiratory Syndrome Occur in Some Hospital	This study was evaluated as part of the 2012 Tran et al systematic review but deemed not to be suitable for inclusion as it did not report on their outcome of interest which was risk of ARI transmission.

			Wards but Not in Others?, **Ignatius T. Yu, Zhan Hong Xie, Kelvin K. Tsoi, Yuk Lan Chiu, Siu Wai Lok, Xiao Ping Tang, David S. Hui, Nelson Lee, Yi Min Li, Zhi Tong Huang, Tao Liu, Tze Wai Wong, Nan Shan Zhong, Joseph J. Sung** **Clinical Infectious Diseases, Volume 44, Issue 8, 15 April 2007, Pages 1017–1025**	The study reports on risk of 'super spreading events occurring' which the authors defined as "development of ≥3 new cases of SARS in a ward during the period from 2 to 10 days after the admission of an identifiable index patient or as the development of a cluster of ≥3 new cases of SARS in a ward during a period of 8 days but without any known sources of SARS." The authors looked at environmental and patient factors such as - Use of High flow 02 therapy via mask (>6L/min) - Use of nebuliser - Performance of resuscitation - Performance of endotracheal intubation - Performance of suctioning of the respiratory tract - Index pt required oxygen supply - Index pt required use of nebuliser - Index pt required use of mechanical ventilation - Index pt required BIPAP ventilation

				They also inspected wards and interviewed staff over period of just over a year from Sept 2004. Medical records were examined. 127 wards in China and Hong Kong included. Multivariate analysis revealed significant risk was associated with - whether any host patients required bi-level positive airway pressure ventilation (OR, 11.82; 95% CI, 1.97–70.80) The authors state that due to small sample sizes “the contribution of certain possible risk factors (such as type of ventilation in the ward and lack of appropriate personal protective equipment and infection control training) could not be entirely ruled out.” Authors concluded that “additional work needs to be conducted with regard to the safe use of oxygen therapy and/or ventilatory support among patients with respiratory infections.” **This study provides very weak evidence that transmission of equal to or more than 3 persons may occur on**

				wards where index patients require BIPAP ventilation, however, this may be related to sicker patients (who require ventilation) having higher viral loads.
Assessment of evidence for non-invasive ventilation	**There is weak evidence to support the concept that non-invasive ventilation does not generate significant aerosols** **There is weak evidence to support the increased ARI transmission risk associated with non-invasive ventilation**			

Procedure: Administration of nebulised saline, drugs or medications	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebulizer treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. **AK Simonds, A Hanak, M Chatwin, MJ Morrell, A Hall, KH Parker, JH Siggers, RJ Dickson.** **Health Technology Assessment 2010;**	In this non-randomised control trial, airborne particle production was assessed during a variety of procedures using an optical particle sizer. Samples were collected at two positions during procedures; adjacent to the subject's mouth (D1), and 1 metre from the subject to represent the typical placement of a healthcare worker during the procedure (D2). 3 participant groups were used during the course of this study; normal controls, subjects with coryzal symptoms, and adult patients with chronic lung disease who were admitted to hospital with an infective exacerbation of their underlying chronic condition. During nebuliser therapy there was a significant increase in all sizes of	**Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.** **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	Systematic review of 10 studies, all of which were considered very low quality evidence on assessment with the GRADE system. Three studies were included on the risk of nebuliser treatment in aerosol transmission. When the results of these studies were pooled the odds ratio for risk of transmission was 0.9 with 95% CI 0.1, 13.6. This suggests that risk of transmission is not increased during nebuliser treatment. However, it is important to note that these three studies had a high level of statistical heterogeneity (73.1%). The authors go on to explain that "in a sensitivity analysis, exclusion of the data of Wong et al. (2004) from meta-analysis yielded an OR of 3.7 (95% CI 0.7, 19.5) with no statistical heterogeneity (I2=0%).

	vol. 14: No. 46, 131-172.	airborne particle at both measurement points, this profile was consistent with the aerosol output from the nebulizer itself rather than from subjects. **This study provides weak to moderate evidence that administration of nebulised saline does not produce significant aerosols**		However, this would not be considered statistically significant as the confidence interval crosses 1. **This study provides very weak evidence that nebuliser treatment does not create an increased risk of transmission via the aerosol route.**
	Characterization of Aerosols Generated During Patient Care Activities. **Caroline A. O'Neil, Jiayu Li, Anna Leavey, Yang Wang, Matthew Hink, Meghan Wallace, Pratim Biswas, Carey-Ann D. Burnham and Hilary M. Babcock; for the Centers for Disease Control and Prevention Epicenters Program.**	Air samples were collected during patient care activities, with each activity being sampled 5 times. The authors state that there was significant aerosol generation during nebulised medication administration, both alone and during bronchoscopy. This conclusion is not based on statistical analysis and so should be considered weak evidence. Furthermore, this study had a number of limitations including a small sample size, and unclear participant selection procedures. The authors note in the discussion that the most likely source for aerosol	**Probable Crimean-Congo hemorrhagic fever virus transmission occurred after aerosol-generating medical procedures in Russia: nosocomial cluster** **Natalia Yurievna Pshenichnaya, Svetlana Alexeevna Nenadskaya.** **International Journal of Infectious Diseases 33 (2015) 120–122**	The case study of a single patient with Crimean-Congo hemorrhagic fever (CCHF), who during her treatment received mucolytics and broncholytics through a compression inhaler (Nebulflaem). 8 healthcare workers, 2 of which monitored the nebulised medicine administration hourly, became infected with CCHF in the days following the patient's death. For 2 members of staff, involved in intubation and ventilation, it is assumed that the method of transmission was aerosol, however for all other infected HCWs this cannot be assumed as they could have had contact with blood or body fluids at other points of care. Healthcare workers providing care in this case study work gloves, gowns and fluid

	Clinical Infectious Diseases, 2017;65(8):1342–8	production during nebulisation is the machine and not the patient. **This study provides moderate evidence that administration of medication via nebulisation does not generate significant aerosols.**		resistant surgical masks, but correct use of this PPE cannot be verified. **The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements.**
Assessment of evidence for use of nebulised saline, drugs or medications	**There is moderate evidence that administration of medication via nebulisation does not produce significant aerosols.** **There is very weak evidence to refute the concept that nebuliser treatment creates an increased transmission risk of ARIs.**			

Procedure: Collection of sputum sample	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
			Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review. **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797**	Systematic review of 10 studies, all of which were considered very low quality evidence on assessment with the GRADE system. Collection of a sputum sample was highlighted as a studied procedure in a single cohort study. OR 2.7; 95% CI 0.9, 8.2. Collection of sputum was not found to be associated with an increased risk of transmission of SARS to HCWs. However, the cohort study did not specify how the sputum sample was collected.
Assessment of evidence for collection of sputum sample	**This study cannot be used to assess the risk associated with collecting a sputum sample as there was no detail given as to how this was done.**			

Procedure: Chest Physiotherapy	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebulizer treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. **AK Simonds, A Hanak, M Chatwin, MJ Morrell, A Hall, KH Parker, JH Siggers, RJ Dickson.** **Health Technology Assessment 2010; vol. 14: No. 46, 131-172.**	In this non-randomised control trial, airborne particle production was assessed during a variety of procedures using an optical particle sizer. Samples were collected at two positions during procedures; adjacent to the subject's mouth (D1), and 1 metre from the subject to represent the typical placement of a healthcare worker during the procedure (D2). 3 participant groups were used during the course of this study; normal controls, subjects with coryzal symptoms, and adult patients with chronic lung disease who were admitted to hospital with an infective exacerbation. However, chest physiotherapy was only performed on the patient group. Chest physio consisted of cycles of deep breathing with percussion or shaking to loosen any secretions, followed by an assisted cough	**Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.** **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	Systematic review of 10 studies, all of which were considered very low quality evidence on assessment with the GRADE system. Chest physiotherapy was investigated by two of the identified cohort studies, both given a VERY LOW grade with a pooled estimate of OR 0.8; 95% CI 0.2, 3.2. **This study provides weak evidence that chest physiotherapy does not increase the risk of SARS transmission via aerosols.**

		initiated manually, augmented by the physiotherapist performing inward and upwards pressure on the lower thorax to aid expectoration, after which the patient rested and cycles were repeated for 10 minutes. Chest physiotherapy resulted in increased production of droplets over 10µm in patients (p=0.003), however these had all fallen out by position D2. Due to the size of these droplets and not finding them at position D2, they would not be classed as aerosols. **This study provides moderate evidence that chest physiotherapy is not an aerosol generating procedure.**		
	Influenza Aerosols in UK Hospitals during the H1N1 (2009) Pandemic – The Risk of Aerosol Generation during Medical Procedures. **Katy-Anne Thompson, John V.**	Air samples were collected around patients with suspected or confirmed lower respiratory tract infection. Any interventions performed during testing were noted and classed as aerosol generating procedures if included in the WHO 2007 or 2009 definitions. Baseline samples were those taken when no WHO defined AGPs were	**Influenza Aerosols in UK Hospitals during the H1N1 (2009) Pandemic – The Risk of Aerosol Generation during Medical Procedures.** **Katy-Anne Thompson, John V.**	The authors of this study calculated risk hierarchy for the investigated procedures using viral titre from air samples and probability of a positive sample. The table produced from these calculations provides model numbers which are an indication of overall risk. It was found that chest physiotherapy, in both WHO AGP models (2007 and 2009),

	Pappachan, Allan M. Bennett, Himanshu Mittal, Susan Macken, Brian K. Dove, Jonathan S. Nguyen-Van-Tam, Vicky R. Copley, Sarah O'Brien, Peter Hoffman, Simon Parks, Andrew Bentley, Barbara Isalska, Gail Thomson, on behalf of the EASE Study Consortium. **PLOS ONE February 2013, Volume 8, Issue 2, e56278**	taking place or at least 30 minutes after an intervention was completed. The presence and proportion of airborne particles containing influenza RNA in size fractions of >7.3 µm, 4–7.3 µm and 0.86–4µm was compared for samples taken at baseline and during AGPs. While it is noted that chest physiotherapy is not a WHO defined AGP the authors included it in their models of both the 2007 and 2009 lists. When included in the 2009 WHO AGP model, the results suggest an increased probability of aerosol production associated with chest physiotherapy (OR 3.06; 95% CI 0.28 – 33.3) however this is not statistically significant. **This study provides weak evidence that chest physiotherapy does not produce significant aerosols.**	**Pappachan, Allan M. Bennett, Himanshu Mittal, Susan Macken, Brian K. Dove, Jonathan S. Nguyen-Van-Tam, Vicky R. Copley, Sarah O'Brien, Peter Hoffman, Simon Parks, Andrew Bentley, Barbara Isalska, Gail Thomson, on behalf of the EASE Study Consortium. PLOS ONE February 2013, Volume 8, Issue 2, e56278**	had a lower risk of infectious aerosol production than baseline samples. The findings of this section of the study show that while there is risk of transmission when providing when providing chest physiotherapy, it is lesser than the baseline level of risk. **This study provides weak evidence that chest physiotherapy does not increase the risk of transmission above baseline levels.**

			Risk factors for SARS transmission from patients requiring intubation: a multicentre investigation in Toronto, Canada. **Raboud J, Shigayeva A, McGeer A, Bontovics E, Chapman M, Gravel D, Henry B, Lapinsky S, Loeb M, McDonald LC, Ofner M.** **PLoS One. 2010;5(5).**	This retrospective cohort study investigated risk factors associated with the transmission of SARS-CoV during performance of high-risk procedures. Results show that there was no statistical difference between the number of HCW performing chest physiotherapy who did not develop SARS and those HCWs who did develop SARS. **This study provides weak evidence that HCWs performing chest physiotherapy are not at higher risk of developing SARS.**
			SARS among critical care nurses, Toronto. **Loeb M, McGeer A, Henry B, Ofner M, Rose D, et al. (2004)** **Emerg Infect Dis 10: 251–255.**	This retrospective cohort study amongst nurses working in two critical care units aimed to determine risk factors for SARS and found that critical care nurses who assisted with chest physiotherapy of SARS patients were not significantly more likely to become infected than nurses who did not.

				This study provides weak evidence that HCWs performing chest physiotherapy are not at higher risk of developing SARS.
Assessment of evidence for Chest Physiotherapy	**There is weak to moderate evidence that chest physiotherapy does not produce significant aerosols.** **There is weak to moderate evidence that chest physiotherapy does not increase risk of transmission.**			

Procedure: Pressurised humidified oxygen	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Evaluation of droplet dispersion during non-invasive ventilation, oxygen therapy, nebulizer treatment and chest physiotherapy in clinical practice: implications for management of pandemic influenza and other airborne infections. **AK Simonds, A Hanak, M Chatwin, MJ Morrell, A Hall, KH Parker, JH Siggers, RJ Dickson.** **Health Technology Assessment 2010;**	In this non-randomised control trial, airborne particle production was assessed during a variety of procedures using an optical particle sizer. Samples were collected at two positions during procedures; adjacent to the subject's mouth (D1), and 1 metre from the subject to represent the typical placement of a healthcare worker during the procedure (D2). 3 participant groups were used during the course of this study; normal controls, subjects with coryzal symptoms, and adult patients with chronic lung disease who were admitted to hospital with an infective exacerbation There was no significant change in airborne particle production during oxygen therapy for any group.	**Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.** **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	Systematic review of 10 studies, all of which were considered very low quality evidence on assessment with the GRADE system. Two cohort studies in this review identified manipulation of an oxygen mask as a procedure with possible risk for SARS transmission to HCWs. The pooled odds ratio was 4.6 with 95% CI 0.6, 32.5, making it not statistically significant. A single cohort study was also included on the administration of high flow oxygen (OR 0.4;95% CI 0.1, 1.7) which was shown to not generate a significant risk of aerosol transmission. A further case control study was included on administration of oxygen (OR 1.0, 95% CI 0.3, 2.8). This study found that there was no association between aerosol

	vol. 14: No. 46, 131-172.	Oxygen therapy was administered for the control and coryzal symptom participants at 60% through a Ventimask, and for the chronic lung disease patients at 24% through a Venturi mask. **This study provides moderate evidence that oxygen therapy by the two studied methods does not generate significant aerosols**		transmission and the administration of oxygen. **This study provides weak evidence that manipulation of an oxygen mask does not pose a risk of transmission. Weak evidence is also provided on administration of oxygen and high flow oxygen suggesting that they do not create an increased risk of transmission**.
			Why Did Outbreaks of Severe Acute Respiratory Syndrome Occur in Some Hospital Wards but Not in Others?, **Ignatius T. Yu, Zhan Hong Xie, Kelvin K. Tsoi, Yuk Lan Chiu, Siu Wai Lok, Xiao Ping Tang, David S. Hui, Nelson Lee, Yi Min Li, Zhi Tong Huang, Tao Liu, Tze Wai Wong, Nan**	This study was evaluated as part of the 2012 Tran et al systematic review but deemed not to be suitable for inclusion as it did not report on their outcome of interest which was risk of ARI transmission. This study reports on risk of 'super spreading events occurring' which the authors defined as "development of ≥3 new cases of SARS in a ward during the period from 2 to 10 days after the admission of an identifiable index patient or as the development of a cluster of ≥3 new cases of SARS in a ward during a period of 8 days but without any known sources of SARS."

			Shan Zhong, Joseph J. Sung, **Clinical Infectious Diseases, Volume 44, Issue 8, 15 April 2007, Pages 1017–1025**	The authors looked at environmental and patient factors such as - Use of High flow 02 therapy via mask (>6L/min) - Use of nebuliser - Performance of resuscitation - Performance of endotracheal intubation - Performance of suctioning of the respiratory tract - Index pt required oxygen supply - Index pt required use of nebuliser - Index pt required use of mechanical ventilation - Index pt required BIPAP ventilation Inspected wards and interviewed staff over period of just over a year from Sept 2004. Medical records examined. 127 wards in China and Hong Kong included. Multivariate analysis revealed significant risk was associated with - whether any host patients (index patient or the first patient with SARS admitted to a ward) required oxygen therapy (OR, 4.30; 95% CI, 1.00–18.43). However, it is important to

				note that the confidence interval contains 1 which calls into question the statistical significance of the results. - Use of a high O2 flow rate mask (>6L/min) (but only for super spreading events defined as 5 cases or more) OR 7.08 (1.30-38.42) p=0.02. The authors state that due to small sample sizes “the contribution of certain possible risk factors (such as type of ventilation in the ward and lack of appropriate personal protective equipment and infection control training) could not be entirely ruled out.” Authors concluded that “additional work needs to be conducted with regard to the safe use of oxygen therapy and/or ventilatory support among patients with respiratory infections.” **This study provides very weak evidence that transmission events may occur more frequently on wards where index patients require oxygen therapy, however, this may be related to sicker patients (who require O2) having**

				higher viral loads and as the authors outline, contributory factors such as PPE compliance and ventilation could not be assessed.
Assessment of evidence for pressurised, humidified oxygen administration	**There is moderate evidence that oxygen therapy does not result in significant generation of aerosols.** **There is weak evidence that manipulation of an oxygen mask does not pose a risk of ARI transmission.** **There is weak evidence that administration of oxygen and high flow oxygen do not create an increased risk of ARI transmission but also very weak evidence that oxygen administration on a ward increases the chances of transmission events.**			

Procedure: Intubation/ extubation	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
	Influenza Aerosols in UK Hospitals during the H1N1 (2009) Pandemic – The Risk of Aerosol Generation during Medical Procedures. **Katy-Anne Thompson, John V. Pappachan, Allan M. Bennett, Himanshu Mittal, Susan Macken, Brian K. Dove, Jonathan S. Nguyen-Van-Tam, Vicky R. Copley, Sarah O'Brien, Peter Hoffman, Simon Parks, Andrew Bentley, Barbara Isalska, Gail Thomson, on behalf**	The presence and proportion of airborne particles containing influenza RNA in size fractions of >7.3 µm, 4–7.3 µm and 0.86–4µm was compared for samples taken at baseline or during WHO defined AGPs. Most of the RNA recovered from the baseline samples was recovered in the >7.3 µm size range (78.7%). In contrast, the % of total RNA collected in each stage size for intubation procedure were: 0.0% for >7.3µm 0.3% for 4 – 7.3µm 0.0% for 0.86 – 4µm An analysis of specific procedures found an increased association with aerosol production with intubation and other related procedures (OR =2.71 (0.15–49.1) although this was not	**Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review.** **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	The review found that tracheal intubation was associated with an increased risk of SARS transmission: tracheal intubation (OR 6.6, 95% CI 2.3-18.9 (4 cohort studies); OR 6.6, 95% CI 4.1-10.6 (4 case-control studies) Limitations: this systematic review included only 10 studies, all of which concerned SARS and all of which were assessed as very low quality by the GRADE system. The review authors caution that the findings should not be generalised to all ARIs because the evidence is limited to SARS. The authors note that their review highlights the lack of high quality studies examining the risk of transmission of organisms responsible for ARIs to healthcare workers caring for patients undergoing AGPs, and highlights the lack of precision in the definition for AGPs.

	of the EASE Study Consortium. **PLOS ONE February 2013, Volume 8, Issue 2, e56278.**	statistically significant and is not solely focused on intubation. The study was likely underpowered to detect a statistically significant difference between the baselines and samples taken during AGPs. The authors acknowledge several other limitations e.g. Baseline samples were taken during activities that did not meet the WHO definition of an AGP; there is a risk that the activities that were being performed were unrecognized AGPs. This study assessed presence of viral RNA only and not live virus and so the viral RNA detected may not be viable. There were in some cases very large variation in the number of airborne particles generated from patient to patient; it is likely that patient specific factors such as stage of infection, age, underlying conditions etc. contribute to the production of aerosols **This study provides weak to moderate evidence of significant aerosol production with intubation**		**This systematic review provides moderate evidence of an increased risk of SARS transmission to HCWs during tracheal intubation.**

		but not of aerosols with detectable influenza RNA.		
			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.** **American Journal of Respiratory and Critical Care Medicine. 169, 11 (2004).**	ICU with 7 SARS patients. Comparison groups: Physicians performing [or nurses assisting] endotracheal intubation on patients with SARS VS. Physicians [or nurses] caring for patients with SARS and not performing [or being present during) endotracheal intubation Both nurses and doctors who performed or were present during endotracheal intubation of SARS patients had a significantly increased risk of developing SARS (RR 13.29; 95% CI=2.99 to 59.04; p=0.003). Eye/face shields were variably employed but N95 respirators, gowns and gloves always worn. Although this study provides evidence that endotracheal intubation is an AGP, it is observational and retrospective. This study assessed actual risk of infection and was well controlled for

				confounders. All patients were cared for in negative pressure isolation rooms. **This study provides moderate evidence that endotracheal intubation increases risk of transmission of SARS**
			Aerosol transmission of severe fever with thrombocytopenia syndrome virus during resuscitation. **Jaeyoung Moon, Hyeokjin Lee, Ji Hoon Jeon, Yejin Kwon, Hojin Kim, Eun Byeol Wang, Choong Won Seo, Sul A. Sung, Su-Hyun Kim, Hyeri Seok, Won Suk Choi, WooYoung Choi and Dae Won Park.** **Infection Control & Hospital**	This case report describes contact of 14 HCWs with a single case of severe fever with thrombocytopenia syndrome virus (SFTFV). The investigation collected data from staff including demographic data, clinical symptoms, signs of SFTS, history of tick bites, animal contacts, routes of possible exposure to risk factors, the use of protective devices, and protective behaviours. Airborne precautions were not put in place before the diagnosis of SFTSV), it is unclear if they were subsequently implemented. Transmission of SFTVS was confirmed (clinical symptoms and RT-PCR) in one doctor who wore droplet precautions and performed endotracheal intubation on the patient, it was noted that frequent suctioning of the patient was required due to naso-oral bleeding.

			Epidemiology (2019), 40, 238–241	Limitations: it is possible the doctor may have contracted the virus from contact i.e. non-AGP related activities. The other clinicians who performed endotracheal intubation/suctioning did not contract the virus. **The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements.**
			Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. **Hae-Sung Nam, Mi-Yeon Yeon, Jung Wan Park, Jee-Young Hong, Ji Woong Son.** **Epidemiology and Health. Volume: 39 2017.**	This report describes the investigation of a case of MERS-CoV transmitted to a HCW during a large hospital outbreak in South Korea in 2015. The HCW was a nurse who performed CPR on an infected patient for around 1 hour. Haemoptysis was continuously observed whilst intubation and suctioning of the airways was performed. CPR was performed in a negative pressure isolation room, a large amount of body fluid was splashed during the procedure and the nurse remained in the room for around 2-3 hours after performing CPR to clean the room. After recovery the nurse noted that her goggles were heavy and had slid down along with

				her surgical mask while performing CPR, in addition CCTV revealed she had touched the masks and goggles with contaminated gloves and had wiped away sweat. Findings from this case should be extrapolated with caution as MERS-CoV is a specific virus that may not replicate the transmission modalities of other pathogens. **The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements**
			Probable Crimean-Congo hemorrhagic fever virus transmission occurred after aerosol-generating medical procedures in Russia: nosocomial cluster **Natalia Yurievna Pshenichnaya,**	This report describes the transmission of CCHF to 8 HCWs who cared for an infected patient (one doctor was also involved in the care of two other infected patients). As part of her care the patient was ventilated in a neutral pressure side room. All staff who has contact with the patient wore gloves, surgical masks and gowns. Six HCWs could potentially have had contact with the patient's blood or body

			Svetlana Alexeevna Nenadskaya. **International Journal of Infectious Diseases 33 (2015) 120–122**	fluids or could have used their PPE inappropriately, however, two staff had no direct or indirect contact with body or fluids of the patient. This study provides moderate evidence that airborne transmission to at least two of the infected HCWs occurred through being in the room when high risk procedures were being conducted. These staff were present in the room during these procedures but had no direct contact with the patient, presumably they had some minimal contact with the patient's environment e.g. door handles, however this is not highlighted as a risk by the authors. Findings from this case should be extrapolated with caution as CCHF is a specific virus that may not replicate the transmission modalities of other pathogens. The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements.

Assessment of evidence for tracheal intubation	**There is weak to moderate evidence to support the concept that tracheal intubation significantly increases aerosol production.** **There is moderate evidence to support the concept that tracheal intubation increases the risk of transmission of an ARI from a patient to a healthcare worker.**

Procedure: Manual Ventilation	Evidence of aerosol production studied		Evidence of transmission risk studied	
	STUDY	**FINDINGS**	**STUDY**	**FINDINGS**
			Possible SARS Coronavirus Transmission during Cardiopulmonary Resuscitation. **Christian MD, Loutfy M, McDonald LC, et al.** **Emerging Infectious Diseases 2004; 10: 287-293**	Procedure: Manual ventilation with a bag-valve mask and chest compressions This report describes the investigation of a possible SARS coronavirus transmission to a healthcare worker (HCW) during CPR. 9 HCWs took part in the resuscitation attempt: 6 nurses (RN), 2 respiratory therapists (RT) and a physician (MD). All the nurses wore PPE considered standard for routine SARS patient care at this hospital consisting of two gowns, two sets of gloves, goggles, a full-face shield (with the exception of RN1 and RN2), shoe covers, hair cover, and N95 disposable respirators that were not fit-tested. RTs and MD wore T4 Personal Protection Systems. The patient was initially ventilated with a bag-valve-mask without a bacterial/viral filter, successful endotracheal intubation was carried out by RT in <30s. No suctioning was required during or after intubation and no

				respiratory secretions or other bodily substances were observed in the environment. A bacterial/viral filter was placed on the bag-valve-mask after the intubation. 3 nurses presented with symptoms of SARS infection; 5 out of 9 involved HCWs consented to serologic testing: 1 positive, 3 negative & 1 indeterminate. The authors postulate 2 explanations that may account for the transmission: 1. Unrecognised breach in contact and droplet precautions occurred 2. Airborne viral load was great enough to overwhelm protection from droplet precautions PPE including non-fit tested N95 disposable respirators If 2 was responsible, the airborne virus may have been generated by the coughing patient pre cardiopulmonary arrest or due to 'cough-like' force produced during chest compressions and ventilations using bag-valve mask. **This study provides inconclusive or very weak association of SARS transmission to HCW via manual**

				ventilation with a bag-valve mask and chest compressions.
			Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review. **Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly.** **PLOs One, 2012, 7(4), e35797.**	The review included ten studies (five case-control; five cohort), all of which investigated the protective measures or the risk factors for transmission of SARS from patients to healthcare workers in intensive care or other hospital settings during the 2002-2003 SARS outbreaks.17 The review found, based on the included studies, that the following procedure present an increased risk of transmission: manual ventilation before intubation (OR 2.8, 95% CI 1.3-6.4 (1 cohort)). The findings of the review suggest that some procedures potentially capable of generating aerosols have been associated with increased risk of SARS transmission to healthcare workers, or were a risk factor for transmission. However, this systematic review included only ten studies, all of which concerned SARs and all of which were assessed as very low quality by the GRADE system. The review authors caution that the findings should not be generalised to all

				ARIs because the evidence is limited to SARS. The authors note that their review highlights the lack of high quality studies examining the risk of transmission of organisms responsible for ARIs to healthcare workers caring for patients undergoing AGPs, and highlights the lack of precision in the definition for AGPs. **This review provides weak evidence that manual ventilation before intubation presents an increased risk of SARS transmission**
			Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. **Hae-Sung Nam, Mi-Yeon Yeon, Jung Wan Park, Jee-Young Hong, Ji Woong Son.** **Epidemiology and Health. Volume: 39,**	This report describes the investigation of a case of MERS-CoV transmitted to a HCW during a large hospital outbreak in South Korea in 2015. The HCW was a nurse who performed CPR on an infected patient for around 1 hour. CPR was performed in a negative pressure isolation room, a large amount of body fluid was splashed during the procedure and the nurse remained in the room for around 2 hours after performing CPR to clean the room. After recovery the nurse noted that her goggles were heavy and had slid down along with her surgical mask while performing CPR, in addition she had

			Article ID: e2017052, 4 pages https://doi.org/10.4178/epih.e2017052	touched the masks and goggles with contaminated gloves and had wiped away sweat. The discussion section appears to include a number of procedures under the term 'CPR' including intubation and suctioning, chest compressions, manual ventilation and defibrillation. The authors refer to the 'mask' worn be the HCW but it is unclear if this is a fluid-resistant surgical mask or a filtering face piece. A number of possible transmission routes were considered including the possibility that the nurse was infected through contact with bodily fluids while adjusting or removing her PPE; however, there remained the possibility that infected aerosols generated during CPR could have entered through a gap between the nurse's goggles and 'mask'. **The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements.**

Assessment of evidence for manual ventilation	There is weak evidence to suggest that manual ventilation before intubation is associated with an increased risk of ARI transmission to HCWs.