

LESSONS FROM COVID

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COVID-19 – Need for action

- In March 2020 in the UK a high possibility that hospital services would be overwhelmed, given modelling of infections requiring respiratory support
 - Low ICU beds per capita compared with Europe (6x Germany, 4x Italy)
 - Oxygen requirement difficult in older hospitals, especially in London
- Need for extra capacity
 - 8 built in England
 - Birmingham, Bristol, Exeter, Harrogate, London, Manchester and Washington
 - First one was all ICU
 - London Nightingale - 4000 bed capacity in an exhibition centre

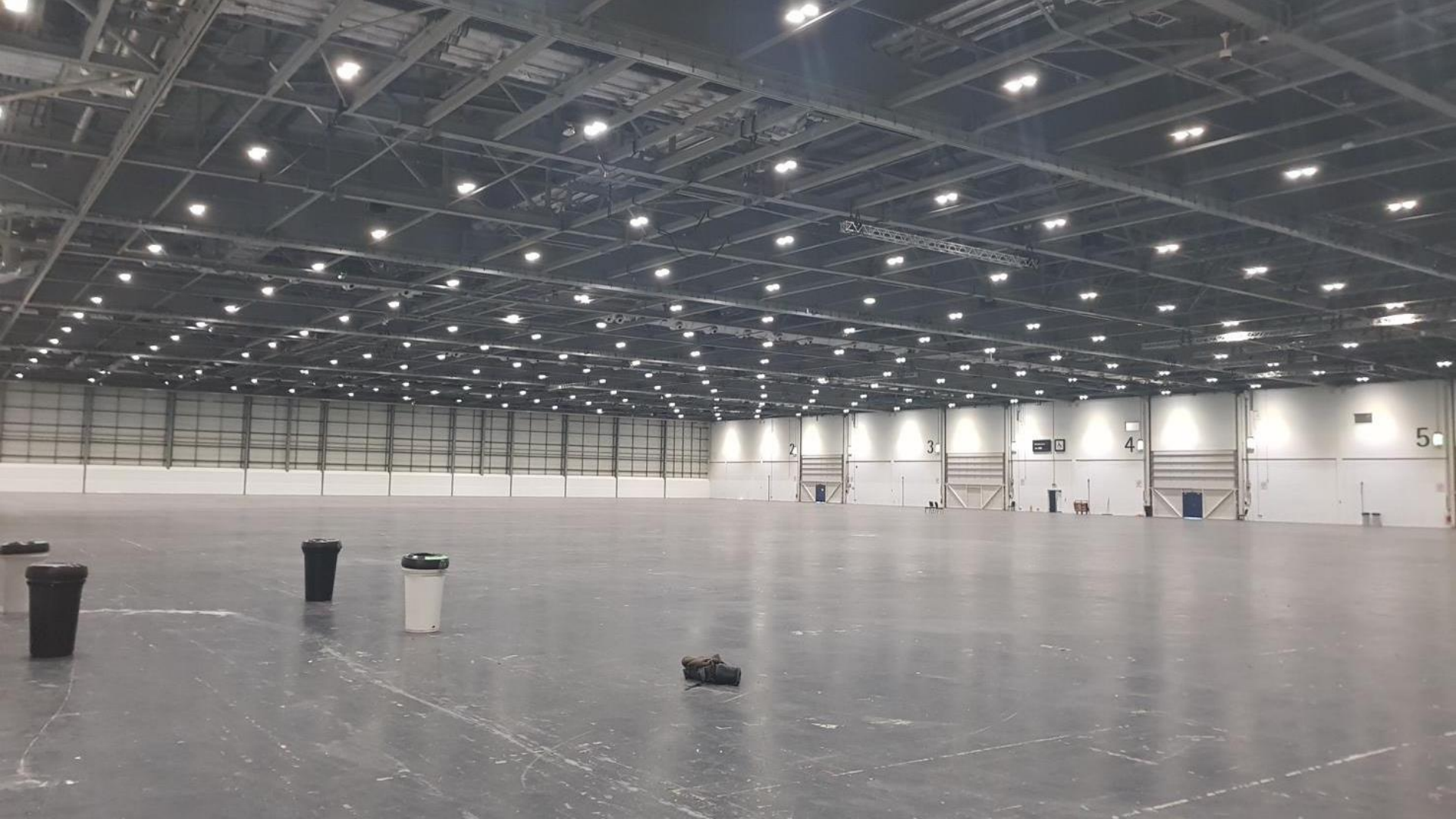
What was available

- 16 individual halls on each side
 - 2 x 600 metre halls either side of a central boulevard - 44,546 m²
 - Big empty rooms with no adjoining areas
 - Six hotels, more than 30 bars and restaurants (all shut) and 3,700 parking spaces on the campus
- Planning – 22nd March 2020
- Opened 3rd April 2020 – admissions 7th April 2020

Problems

- Physical
 - No services apart from power
 - No oxygen
 - No hot water
 - No drainage
 - No washing facilities or toilets for patients
 - But all ICU
- No staff – 1 ICU nurse/6 patients





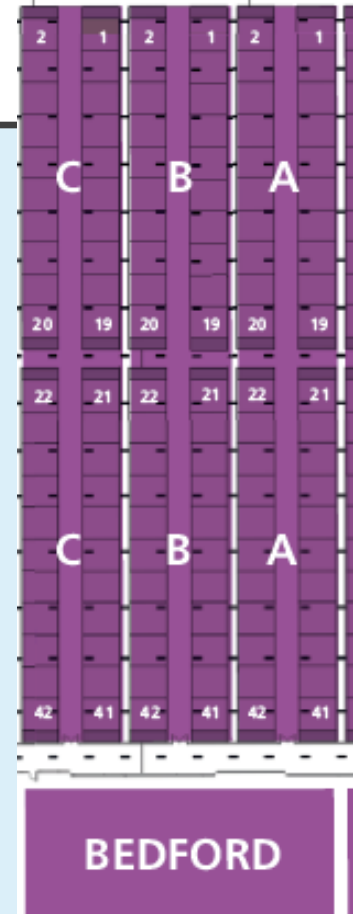
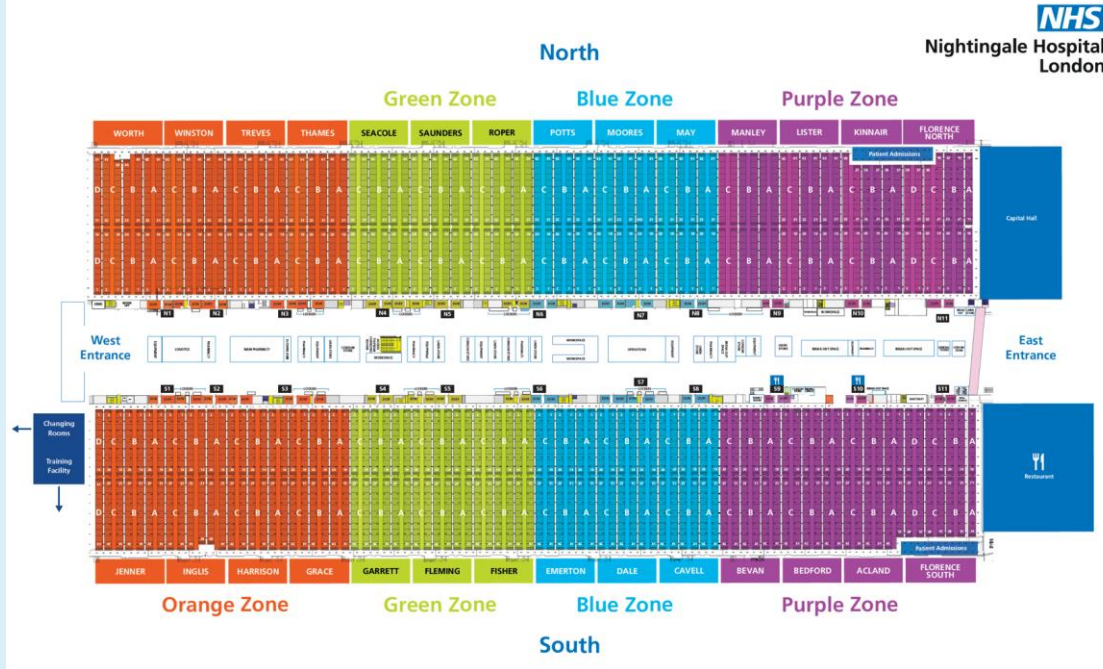


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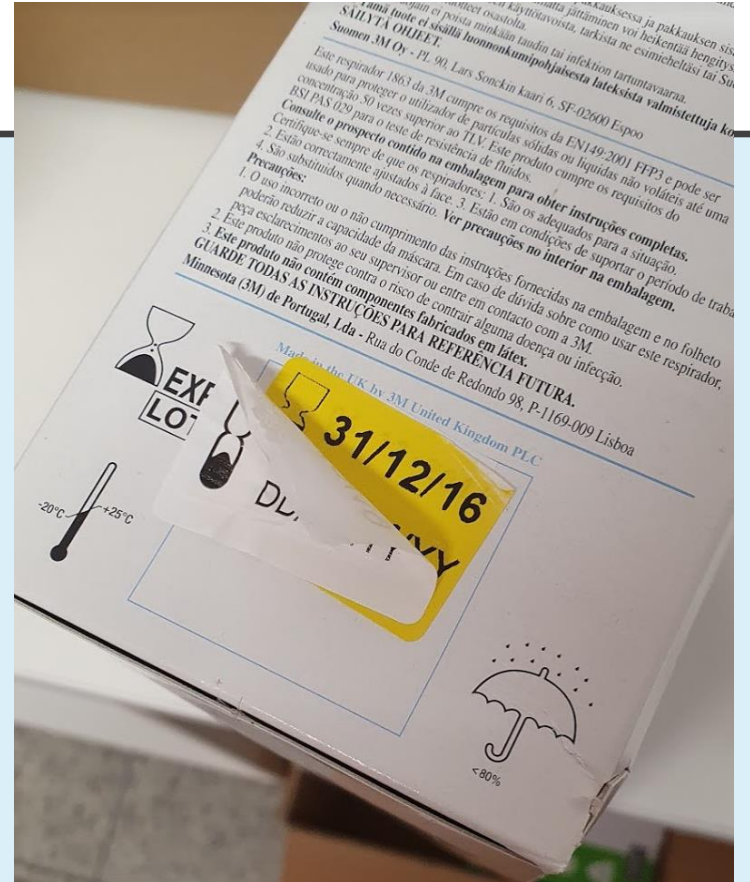


The Scale



PPE

- Whole clinical area designated as AGP
 - FFP3 Mask – so fit testing (outside contractors used)
 - Gown – water repellent
 - Gloves – base layer
 - Visor – reused for 4 day shift pattern
- Logistics of getting staff in and out
 - Facilities unsuitable – small rooms
 - Original modelling showed that it would take over 3 hours to get a shift in to the unit



HCAI Issues

- No CDI, MDR Gram-negatives (that we knew of)
- One MRSA Bacteraemia - No screening
- But 16 line-associated bloodstream infections
 - Every patient had multiple devices
 - Quite a few femoral CVCs
 - Facilities for ANTT poor – we only really had the bed space
 - Other Nightingales had clean utility rooms etc
 - Nightingale 2 had isolation facilities



Nightingale 2 ... the return

- Reopened January 2021
- Completely different setup
- 300 Rehabilitation pathway beds aimed at easing the pressure on London Hospitals
- No COVID Patients (allegedly)



Changes in bacteraemia

- Significant variation, but not in all organisms
 - Denny S, et al. *BMC Infect Dis.* 2021;21(1):556. 10.1186/s12879-021-06159-8
- *S. pneumoniae*, *S. aureus* unchanged
- Community-associated Enterobacterales infections significantly down
 - Actual?
 - Effect of PH 'stay home' messaging?
 - What happened to them?
 - Community ABX prescribing also down
 - Zhu N, et al. *Clin Microbiol Infect.* 2021. 10.1016/j.cmi.2021.02.007
- CoNS up (CLABSI and non-CLABSI)

Change in CNS

- Why?
- Technique?
- Physical environment?
- Staffing?
- PPE?
- Lack of equipment?
- Nightingale experience possibly all of the above
- Global issue
- Esquer Garrigos Z, et al. *Infect Control Hosp Epidemiol.* 2021;1-3. 10.1017/ice.2021.292

CoNS and COVID - an unwelcome partnership
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1. Introduction
Most ICU patients will have central venous access, which has been associated with an increase in blood culture (BC) contamination rate. Using Coagulase Negative Staphylococci (CoNS) as a surrogate marker for BC contamination from central or peripheral cultures, we saw increased contamination levels in:
• 2 COVID-19 adult intensive care units
• 1 non-COVID-19 adult intensive care unit

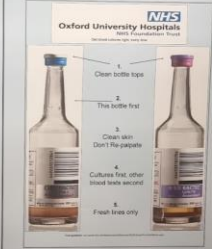
2. Methods
We compared BC contamination rates from 4 adult ICU areas for January to March 2021 with the same time periods in 2020. We also monitored central line associated blood stream infection rates (CLABSI) due to CoNS.

3. Results
• CoNS positive BCs rates (% of total) in adult ICU areas were 4.0% Jan-Feb 2020 vs. 10.9% Jan-Feb 2021 ($p=0.001$)
• In comparison, the rates in March 2020 and 2021 were 7.8% and 3.3%
• The reduction in proportion of CoNS in BCs between Jan-Feb 2021 and March 2021 was also significant at $p=0.001$
• In March 2021, BC contamination rate returned to baseline as COVID pressures reduced
• No CLABSI attributable to CoNS were seen in 2020 (2020). Of 144 CoNS isolates in 2021, only 8 met the CDC definition for CLABSI

4. Discussion
We hypothesise through observations that COVID pressures contributed to the increase in BC contamination rates by:
• Increased bed capacity
• Overcrowding
• Reduced nurse to patient ratio
• Pruning of patients
• Seasonal long sleeve gowning
• Double gloving compromised hand hygiene and aseptic technique
Careful review of CoNS rate aids monitoring of CLABSI. The number of CLABSI attributable to CoNS is low.

Recommended contamination rate of no more than 2-3 %
Contamination is patient safety issue leading to increases in antimicrobial use, length of stay, lab workload, costs

4. References
1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/97963/19_116_2.pdf



PPE Issues in ITUs

- Tendency for staff to think of the PPE that they put on in donning as normal PPE and that was all that was needed
- But for different tasks or for when moving between patients they were asked to wear a further layer of gloves +/- apron
- Would absolutely have gone for short-sleeved gowns



The second layer
is for my patient

Disinfection of gloves

- Examined resistance of 100% powder-free nitrile gloves, composed of nitrile Butadiene rubber exposed to disinfectant compared with a control
- For the tensile test, thickness of each glove was measured with a micrometer
- Seven most commonly used disinfectants in healthcare selected
 - CHG, H₂O₂, Ethanol, Ethanol and I-Propanolol and combinations
- Force required to break decreased with all alcohols
 - In the case of 70% alcohol, 60% of the effort required, all alcohol products lost 25% of strength
 - Garrido-Molina JM, et al. *J Hosp Infect.* 2021;107:5-11. 10.1016/j.jhin.2020.09.015

Impact of PPE on physical health of staff

- Skin reactions
 - Redness, blanching (33%), itchiness (22%), and pressure damage (12%)
 - predominantly at the bridge of the nose and ears
- Mean time spent using PPE was 9.2 ± 2.6 hours.
- Mean time in which PPE was removed was 0.5 ± 0.1 hours
- 64% of participants reported wearing PPE for more than 2 hours without relief
 - significant associations ($P < .05$) between the adverse skin reactions with both the average daily time of PPE usage and the frequency of PPE relief
 - Abiakam N, et al. *Int Wound J*. 2021;18(3):312-322. 10.1111/iwj.13534

Dermatological issues

- Allergic Contact Dermatitis (ACD) and Irritant Contact Dermatitis (ICD) both increased
 - Normally 20% : 80% split
 - Facial pruritis common
 - Retroauricular dermatitis from ear loops (much cheaper and quicker to produce)
 - Periodic change to tie-up version may alleviate
 - Yu J, et al. *J Am Acad Dermatol*. 2021;84(2):486-494. 10.1016/j.jaad.2020.09.074
- Use of Duoderm can alleviate symptoms but may affect the seal of an N95
- Non-CE marked masks have a higher incidence of dermatoses
 - Damiani G, et al. *Ital J Dermatol Venerol*. 2021;156(2):220-225. 10.23736/S2784-8671.21.06895-4

Impact of IPC Precautions on airway management

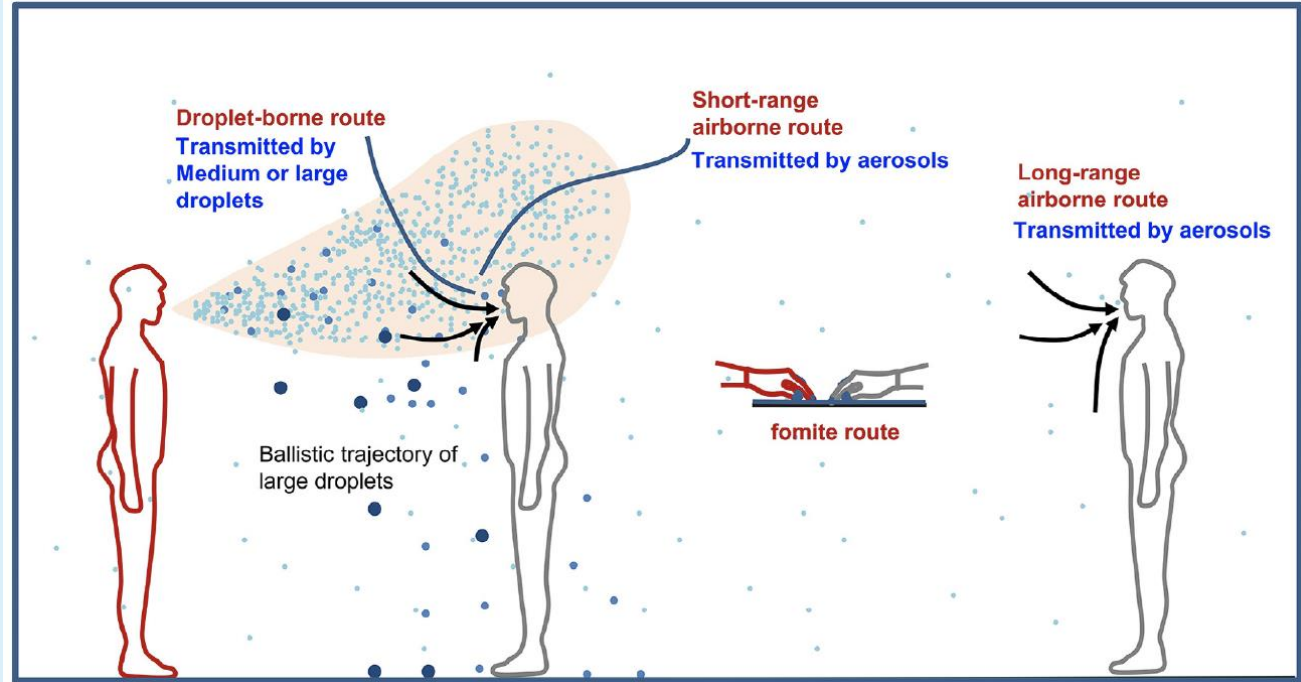
- Modifications to standard intubation practice to reduce the risk to staff
 - aerosolisation reduction, comprehensive PPE for all intubations, regular low fidelity simulations and pre-drawn medications
- Hypoxia higher compared to pre-COVID-19 (18.4% vs 9.6%, $P < 0.005$) despite the first attempt success rate rate remaining very high (95.6% vs 93.8%, $P = 0.42$) and intubation undertaken by more senior staff (Consultant 55.9% vs 22.6% pre-COVID-19, $P < 0.001$)
 - Groombridge CJ, et al. *Emerg Med Australas*. 2021. 10.1111/1742-6723.13809

Dismantling the Myths

- I always thought I didn't know enough. 2020 confirmed it
- Tang, J.W., et al., *Dismantling myths on the airborne transmission of severe acute respiratory syndrome coronavirus (SARS-CoV-2)*. J Hosp Infect, 2021. Online since December
- A nicely written disassembly of myths and misconceptions
 - “Aerosols are droplets with a diameter of 5 μm or less”
 - “All particles larger than 5 μm fall within 1-2 m of the source”
 - “If it's short range, then it can't be airborne”
 - “If the basic reproductive number, R_0 , isn't as large as for measles, then it can't be airborne”
 - “If it's airborne then surgical masks (or cloth face coverings) won't work”
 - “The virus is only 100 nm (0.1 μm) in size so filters and masks won't work”
 - “Unless it grows in tissue culture, it's not infectious”

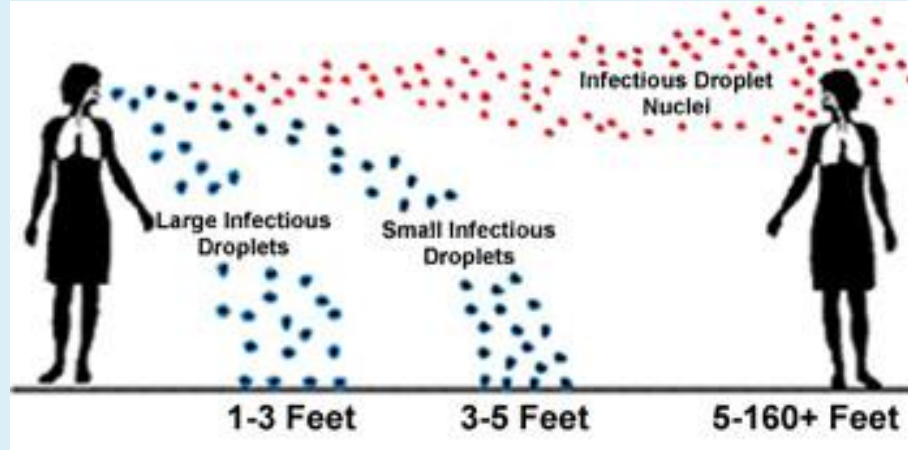
IN THE BEGINNING..

- Contact and droplet thought to be the predominant mode of spread
 - Wei, J. & Y. Li (2016) Airborne spread of infectious agents in the indoor environment. *Am J Infect Control*, 44, S102-8.
- Based on 'old' knowledge



- Large droplets ($>100\ \mu\text{m}$) : Fast deposition due to the domination of gravitational force
- Medium droplets between 5 and $100\ \mu\text{m}$
- Small droplets or droplet nuclei, or aerosols ($< 5\ \mu\text{m}$): Responsible for airborne transmission

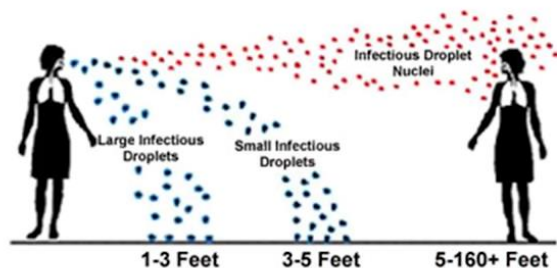
Original position from WHO etc



- Route of transmission likely to be droplet spread through close contact with infected individuals
- R_0 2.5-3, similar to influenza (1918 Pandemic was 2.8), compare with Chicken pox (3.7-5) and measles (12-18)

Not only from WHO

Control: droplet or airborne?



- Route of transmission is likely to be droplet spread through close contact with infected individuals
- R_0 2.5-3, similar to influenza (1918 Pandemic was 2.8), compare with Chicken pox (3.7-5) and measles (12-18)



SARS-1 and SARS-2

- The same but different
 - SARS-1 took 8 months to infect just over 8,000 people before containment
 - SARS-2 took 5 months to infect 3,000,000 people and was not contained
- One difference was the role of asymptomatic spread
 - Gandhi M, et al. Asymptomatic Transmission, the Achilles' Heel of Current Strategies to Control Covid-19. *N Engl J Med*. 2020;382(22):2158-2160. doi:10.1056/NEJMe2009758

What was not known/recognised in early 2020

- Spread can be from symptomatic OR asymptomatic
 - Studies suggest that at least 50% of infections come from an asymptomatic person
 - Johansson, M.A., et al., SARS-CoV-2 Transmission From People Without COVID-19 Symptoms. JAMA Netw Open, 2021. 4(1): p. e2035057.
- Viral load in people can vary by up to 6 times
- People are at their most infectious in the early stage
- People undergoing AGPs are likely to be at a later stage of the disease
- Change in variants also changes transmission dynamics

Surfaces

- Viable viruses can survive on surfaces for up to 72 hours
 - van Doremalen N, et al. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *New England Journal of Medicine*. 2020;382(16).
- Transmission possible but unusual
 - Meyerowitz EA, et al. Transmission of SARS-CoV-2: A Review of Viral, Host, and Environmental Factors. *Ann Intern Med*. 2021;174(1):69-79. doi:10.7326/M20-5008
- However how would it transmit from surfaces?
 - Touch of a surface and transfer to mucous membranes



Surface contamination

- Samples collected from 75 surfaces; low (floor to 10cm), medium (1m) and high (>1.4m above floor level)
- 29% positive, 58% of which were high and 37% from low – so not high touch
- High surfaces could only have been contaminated via the air, as ‘droplets’ would have fallen
 - Thylefors J, et al. Detection of SARS-CoV-2 RNA on surfaces in a COVID-19 hospital ward indicates airborne viral spread. *J Hosp Infect.* 2022. doi:10.1016/j.jhin.2022.02.025

Is viable virus in the air?

- Viable virus of the same strain as the patients
- Air samples 2-4.8m away from the patients
- No Aerosol-Generating Procedures (AGPs) performed
 - Lednicky JA, et al. Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients. *Int J Infect Dis.* 2020;100:476-482. doi:10.1016/j.ijid.2020.09.025
- Virus detected in hallway air outside patient rooms
 - Santarpia JL, et al. Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care. *Sci Rep.* 2020;10(1):12732. doi:10.1038/s41598-020-69286-3

Generation of Aerosols

Aerosol-generating procedures (AGPs)	Aerosol-generating Behaviours
Intubation	Breathing
Suction of a ventilated patient	Talking
Bronchoscopy	Shouting
Sputum induction	Singing
Tracheostomy	Sneezing
	Coughing
	Whispering

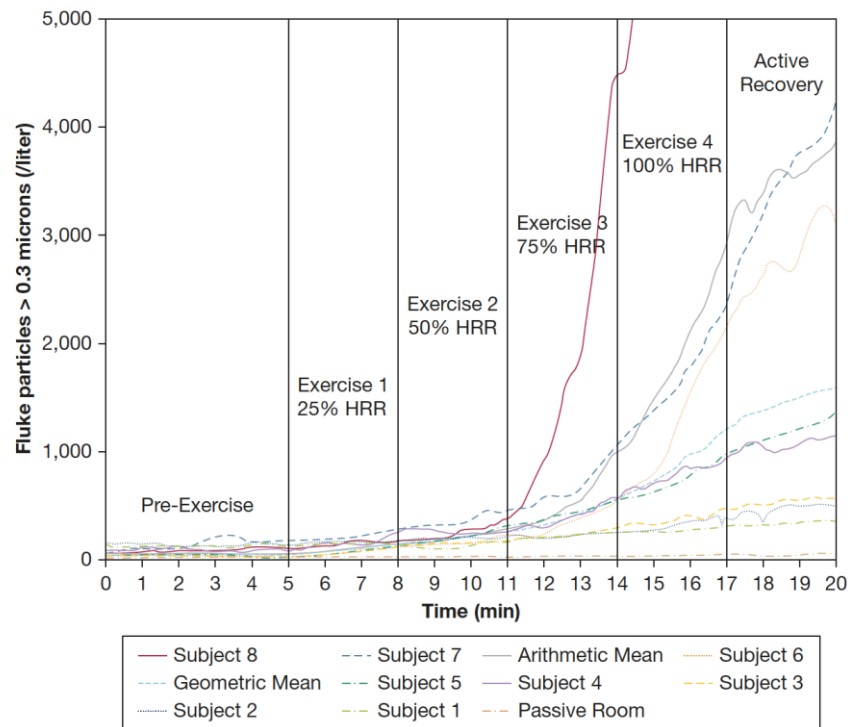
There is no international (or national consensus)

Even quiet speech is a risk

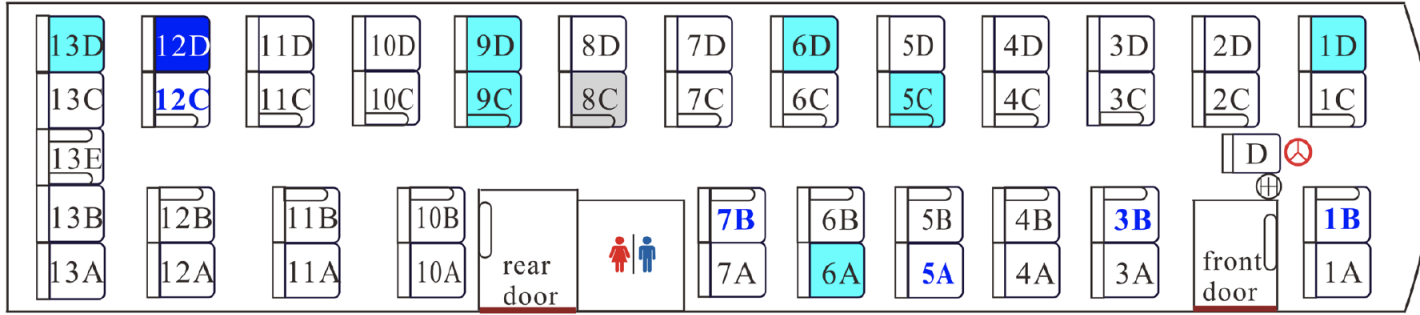
- Settling times of droplets, suspended virus significantly affected by droplet composition
 - Aerosol resulting from 30s of continued speech has settling time and a viable viral dose an order-of-magnitude higher than in a short cough
 - Time-of-flight to reach 2m is only a few seconds resulting in a viral dose above minimum to infect
 - physical distancing in absence of ventilation is insufficient to provide safety for long exposure times de Oliveira PM, et al Proc Math Phys Eng Sci. 2021;477:20200584
- Observations confirm that there is a substantial probability that normal speaking causes airborne virus transmission in confined environments
 - Stadnytskyi,V., et al., The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission. Proc Natl Acad Sci U S A, 2020. 117(22): p. 11875-11877.

What about exercise?

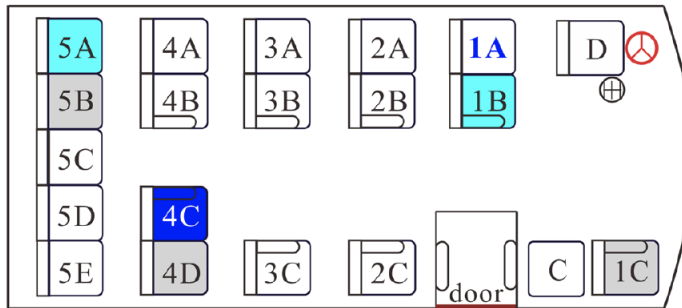
- Aerosol generation increases exponentially with effort
 - Sajgalik P, et al. Characterization of Aerosol Generation During Various Intensities of Exercise. *Chest*. 2021;160(4):1377-1387. doi:10.1016/j.chest.2021.04.041
- Air filtration is effective in rapid removal of aerosols
 - Garzona-Navas A, et al. Mitigation of Aerosols Generated During Exercise Testing With a Portable High-Efficiency Particulate Air Filter With Fume Hood. *Chest*. 2021;160(4):1388-1396. doi:10.1016/j.chest.2021.04.023



Bus Travel



(a)



Index case



New infections

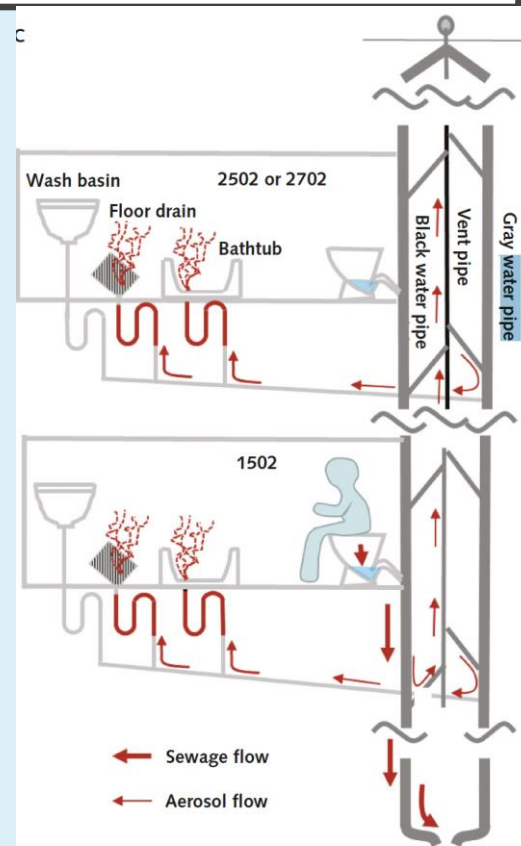


Mask wearers



AND IT IS NOT JUST RESPIRATORY AEROSOLS

- 9 infected patients in 3 families
- No transmission in elevator, elsewhere and no contact
- Families lived in 3 vertically aligned flats connected by drainage pipes in master bathrooms
- Both observed infections and locations of positive environmental samples consistent with vertical spread of virus-laden aerosols via stacks and vents
 - Kang M, et al. Probable Evidence of Fecal Aerosol Transmission of SARS-CoV-2 in a High-Rise Building. *Ann Intern Med.* 2020;173(12):974-980. doi:10.7326/M20-0928
- We already knew this..
 - Yu IT, Li Y, Wong TW, et al. Evidence of airborne transmission of the severe acute respiratory syndrome virus. *N Engl J Med.* 2004; 350:1731-9. [PMID: 15102999]

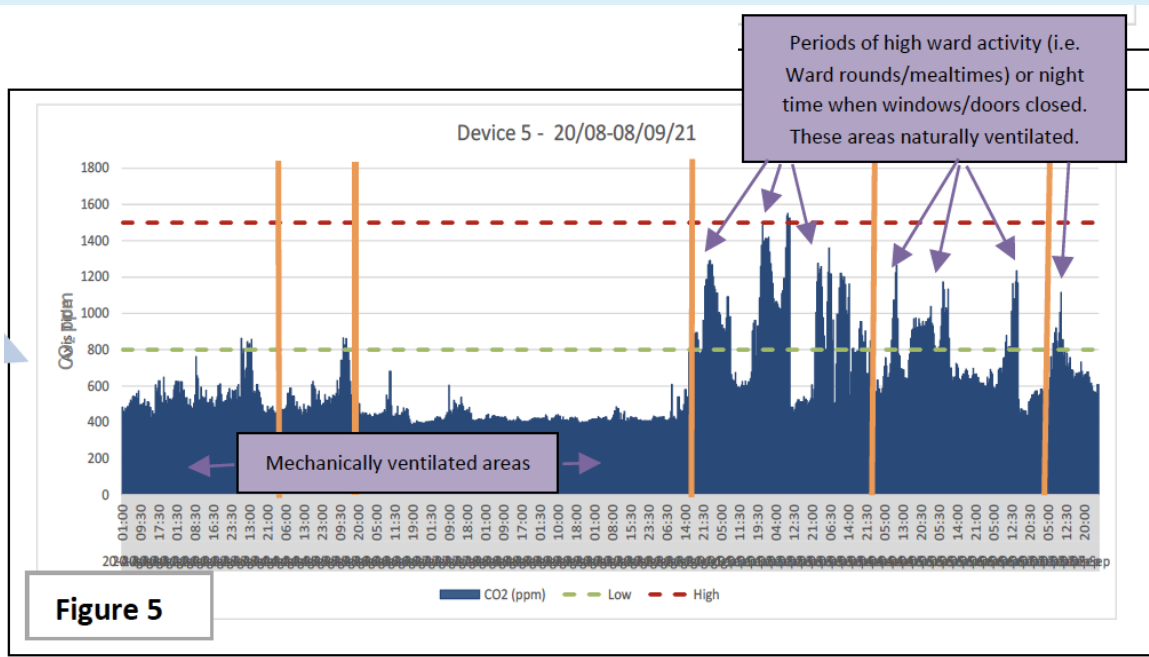


How can you tell if ventilation is poor

- CO₂ monitors will give you some idea but actually, people nodding off is a reasonable proxy!
- Indoor air CO₂ concentrations in hospital rooms commonly peaked above recommended levels, especially during morning care and rooming-in (room sharing)
- But don't tell you how if those infected are around you have and how infectious they are
- Laurent MR, et al. Monitors to improve indoor air carbon dioxide concentrations in the hospital: A randomized crossover trial. *Sci Total Environ.* 2022;806(Pt 3):151349. doi:10.1016/j.scitotenv.2021.151349

Recent Abstract at ECCMID

- Sharon Bamber, Clinical Scientist at the Wirral Uni Hosp Trust
- Placed CO₂ monitors to look for areas with poor ventilation
- 9%
- HEPA filtration installed
- Does not affect CO₂



WHO Advice

- WHO Tweet in 2020: "FACT: #COVID19 is NOT Airborne"



- 23rd December 2021: "COVID is Airborne"
 - quietly edited to state that a person can be infected "when infectious particles that pass through the air are inhaled at short range", a process otherwise known as "short-range aerosol or short-range airborne transmission"
 - Transmission can occur through "long-range airborne transmission" in poorly ventilated or crowded indoor settings "because aerosols can remain suspended in the air or travel farther than conversational distance".

Combating airborne particles

- ACI 500 HEPA 14 (Filtrex, Harlow, UK)
- Airborne SARS-CoV-2 detected in COVID ward before activation of 'portable' HEPA-air filtration, but not during the week of filter operation
 - SARS-CoV-2 was again detected when filter off
- Airborne SARS-CoV-2 infrequently detected in ICU
 - Not a shock..
- Filtration significantly reduced other microbial bioaerosols in both settings
 - Conway Morris A., et al. The removal of airborne SARS-CoV-2 and other microbial bioaerosols by air filtration on COVID-19 surge units. CID (2021) IP



Bioaerosol reduction

- Examined extracted nucleic acid preparations to high-throughput qPCR system to detect a range of viral, bacterial, and fungal pathogens
 - In week one, detected nucleic acid from multiple viral, bacterial, and fungal pathogens on all sampling days
 - When air filter switched on, detected yeast targets only on a single day, with a significant reduction ($p=0.05$) in microbial bioaerosols when the air filter was operational
- So potentially useful for other issues (and there were clues a few years ago)

Back in the day, when MRSA was a problem

- Concern about MRSA environmental contamination from carriers
 - Without air filtration, between 80% and 100% of settle plates in isolation rooms were positive for MRSA
 - mean number of MRSA colony-forming units (cfu)/10-h exposure/plate ranging from 4.1 to 27.7
 - rate of contamination from each patient was significantly reduced by 75-93%, directly related to the rate of air filtration
 - Boswell TC, Fox PC. Reduction in MRSA environmental contamination with a portable HEPA-filtration unit. J Hosp Infect. 2006;63:47-54

Interest before COVID

- Quantitatively assessed if air decontamination could also reduce environmental surface contamination
- Two bacteria (*Staph. aureus* & *Acinetobacter baumannii*), and a spore-former (*Geobacillus stearothermophilus*) tested as representative airborne bacteria
 - Used HEPA/UVC (unspecified HEPA) https://www.amazon.co.uk/GermGuardian-Purifier-Allergies-Cleaner-Guardian-dp-B01CTN024Y/dp/B01CTN024Y/ref=dp_ob_title_kitchen
- Results
 - reduced viability levels of all tested bacteria in the air by $>3 \log_{10}$ ($>99.9\%$) in 45 min
 - average reductions in surface contamination for *S. aureus* (97%), *A. baumannii* (87%) and *G. stearothermophilus* (97%)
- Continuous operation of an air decontamination device can lead to ongoing reductions in pathogens in air and surfaces.
 - Zargar B, et al .A quantitative method to assess the role of indoor air decontamination to simultaneously reduce contamination of environmental surfaces: testing with vegetative and spore-forming bacteria. *Lett Appl Microbiol.* 2019;68:206-11.

Positive unintended consequences

- Blue skies – 20-30% reduction in air pollution
- Crime reduced
- Children more willing to take hygiene measures like hand washing more seriously
- Death rates in young adults significantly reduced
 - Fewer cars, less RTAs (although some excessive speeds)
- Reduction in STDs and an improvement in willingness to take on board contact tracing
 - Mmeje OO, et al. *J Adolesc Health*. 2020;67(3):326-327.
10.1016/j.jadohealth.2020.06.019

Locking Down – Many Negatives

- Health promotion activities ground to a halt; increase in health inequalities, especially to the young
 - Alexander SA, et al. *Health Promot Int.* 2021. 10.1093/heapro/daab015
- Societal needs need to be taken into account
 - Closing churches in the USA when some were going more often; churches saw an increase of 81% in distance visitors had to travel to attend
 - Althouse BM, et al. *medRxiv.* 2020. 10.1101/2020.08.21.20179473
- Impact on mental health; an 'effective' strategy such as lockdown/quarantine has consequences beyond the infection itself
 - Chiesa V, et al. *J Public Health (Oxf).* 2021. 10.1093/pubmed/fdab102



Concluding

- ‘Experts’ may have got it wrong by not listening to the Experts – a disconnect between disciplines
- But we can still learn
 - Ventilate
 - Appropriate PPE
 - Building design
 - Multidisciplinary approach
 - Staffing
 - Training
- Because we will need it for next time



Russ Jones

@RussInCheshire

Replying to [@PatrickHanrahan](#)

Oh, I love being wrong. Every time I'm wrong I tell people about it loudly. I'd much rather be wrong and learn something, rather than claim to be right all the time and remain an idiot.

10:19 · 26 Apr 22 · [Twitter Web App](#)