Dental Aerosol

牙科氣霧傳播對策

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- Dentist
- Taiwan
- 2020

Dental Aerosol

- Introduction 簡介
- Aerosols from scaling 洗牙散佈分析
- Size classification 顆粒大小分類
- Aerosols in Dental Office 診間氣霧分佈
- Virus in aerosol 氣霧中的病毒
- Coronavirus 冠狀病毒特性
- Protective strategy 保護措施
- Working with loupes 防疫中的放大鏡應用
- Risk Assessment 風險評估

Introduction

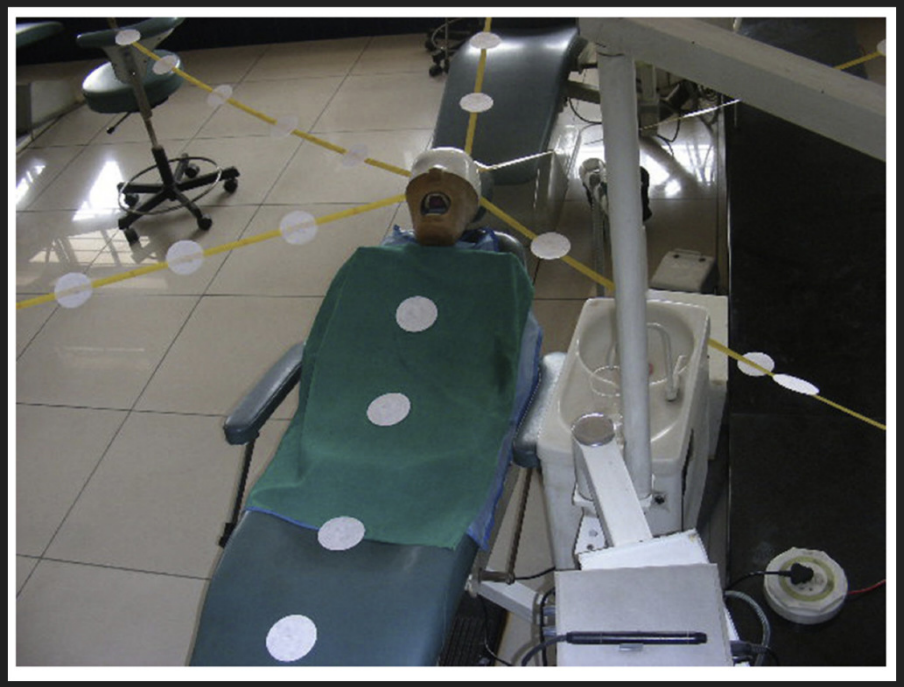
- What if COV-19 spread in community for a long time like Influenza but without vaccine?
  如果疾病具有社區傳播特性如流感卻無疫苗
- And we need to treat dental disease... Emergency or asymptomatic carrier
  而我們如何在治療病人中避免被感染
- Screen and Infection Control
  基本的篩選病患與感控是必要的
- How about Invisible Aerosol
  我們要如何在臨床工作中面對看不到的氣霧感染風險

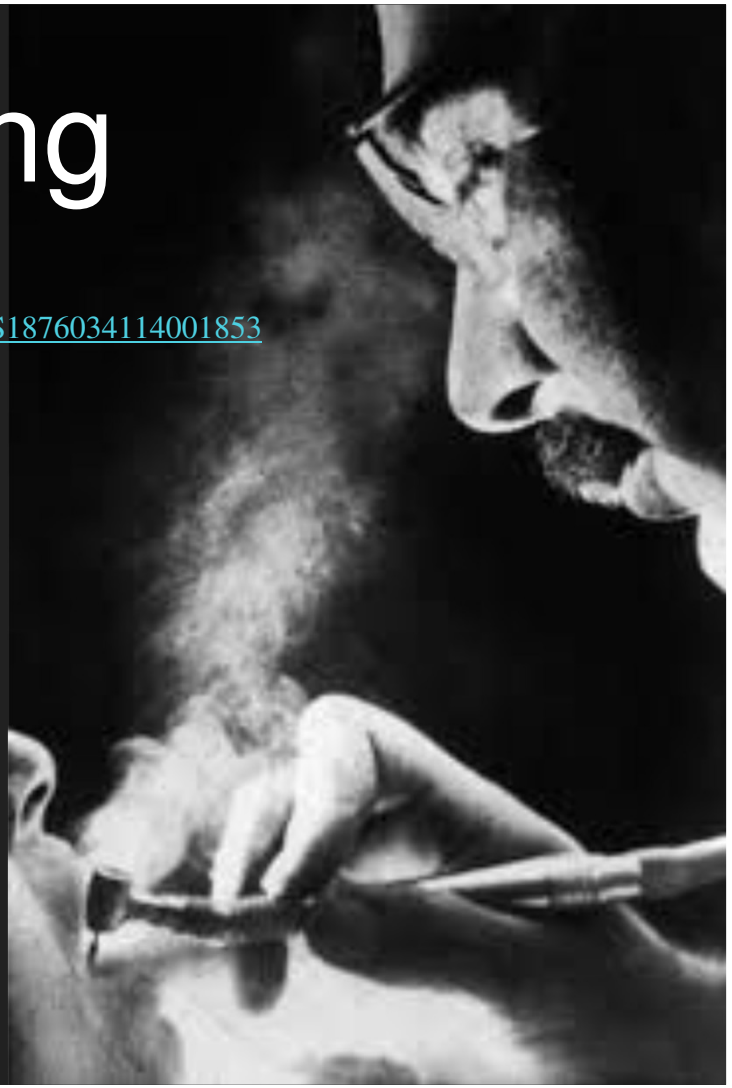
Introduction

- Exposure to aerosols used to be not a significant occupational health risk for dental professionals.
  過去牙科環境中產生的氣霧並不會特別造成職業傷害
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6135984/
- Now with COVID-19, it is a different story.
  武漢肺炎後情況不同了

Aerosols from scaling

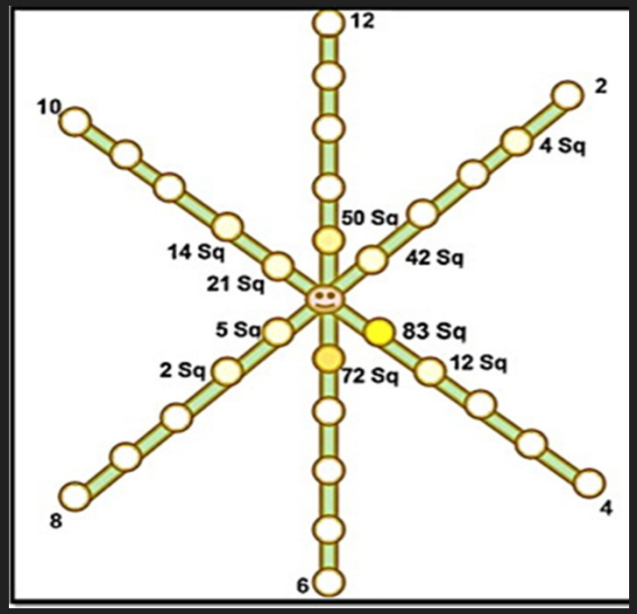
- Dissemination of aerosols
  洗牙過程中產生的氣霧分佈 https://www.sciencedirect.com/science/article/pii/S1876034114001853





Aerosols from scaling

- Right after scaling
  洗牙後立刻分析氣霧分佈, 大都在2ft(60cm)內, 尤其是30cm內



Position	Surface area (cm^2)				
	1 ft	2 ft	3 ft	4 ft	5 ft
12 o'clock	50	–	–	–	–
2 o'clock	42	–	–	4	–
4 o'clock	83	12	–	–	–
6 o'clock	72	–	–	–	–
8 o'clock	5	2	–	–	–
10 o'clock	21	14	–	–	–

Aerosols from scaling

- Aerosols can spread 1~2 ft away from mouth within 30 mins.
  氣霧三十分鐘內可散佈在30~60cm遠處
- Maximum contamination in right arm of dentist / left arm of assistant
  醫師右手和助理的左手受到汙染最多
- Inside of face mask
  外科口罩內側也有!!!

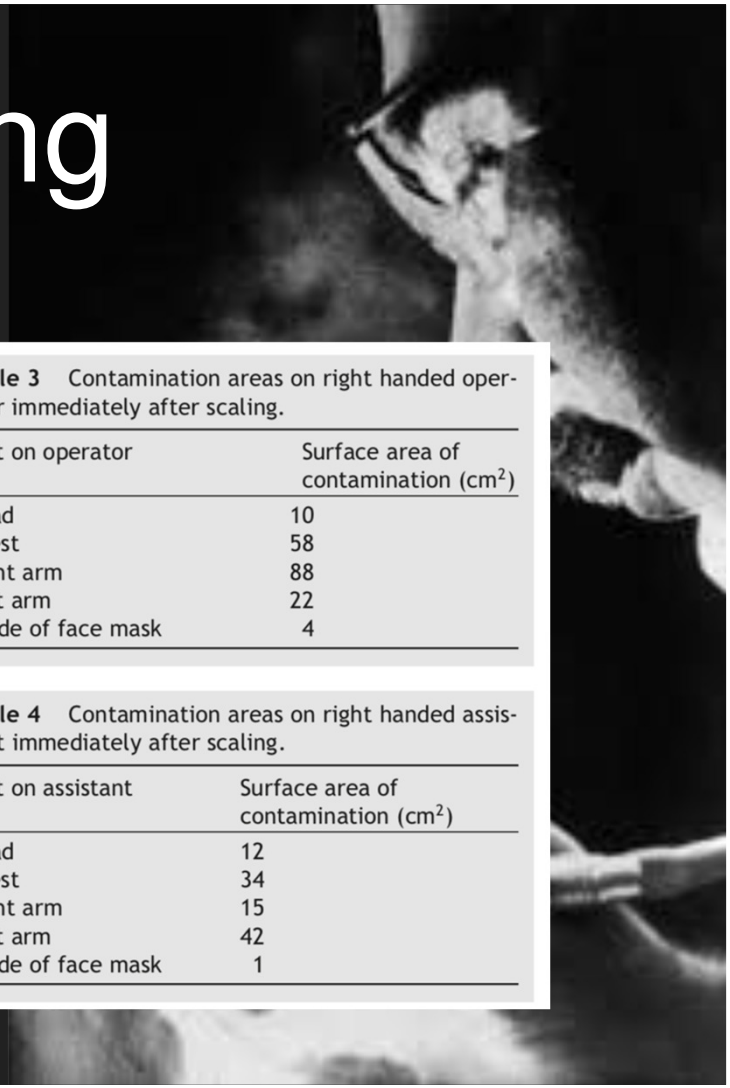


Table 3 Contamination areas on right handed operator immediately after scaling.

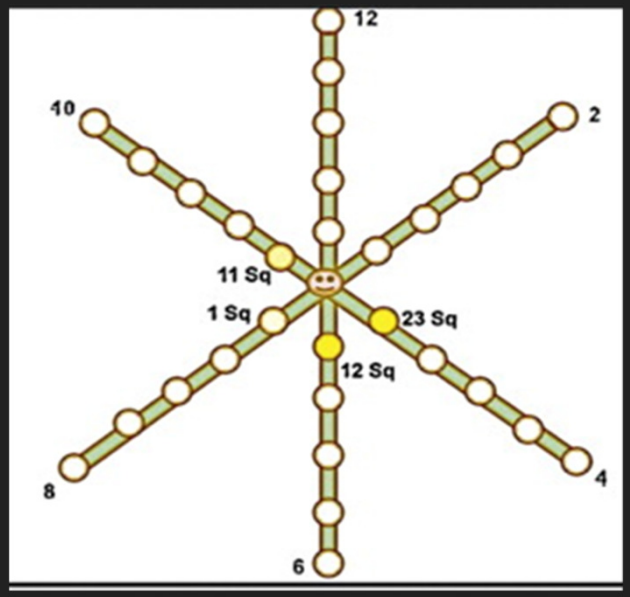
Part on operator	Surface area of contamination (cm^2)
Head	10
Chest	58
Right arm	88
Left arm	22
Inside of face mask	4

Table 4 Contamination areas on right handed assistant immediately after scaling.

Part on assistant	Surface area of contamination (cm^2)
Head	12
Chest	34
Right arm	15
Left arm	42
Inside of face mask	1

Aerosols from scaling

- 30 mins later after scaling, within 2 ft
  30分鐘內主要散落在30公分左右的範圍 無法達到60公分遠處



Position	Surface area (cm^2)				
	1 ft	2 ft	3 ft	4 ft	5 ft
12 o'clock	–	–	–	–	–
2 o'clock	–	–	–	–	–
4 o'clock	23	–	–	–	–
6 o'clock	12	–	–	–	–
8 o'clock	1	–	–	–	–
10 o'clock	11	–	–	–	–

Size Classification

- Spatter >50 μm
  fall on surface quickly
  較大顆粒會較快掉落於表面, 適當隔離感控即可
- Droplet ≤ 50 μm
  Suspend in air till evaporate
  足以懸浮於空氣中, 面罩口罩可防護
- Droplet nuclei < 10 μm
  Remain airborne for 30 mins ~ 2 hrs
  可懸浮於空氣中半小時以上, 有吸入風險
- Surface contamination / Airborne transmission
  可能造成表面接觸性感染 也有空氣傳播的可能性

Size Classification

- < 5 μm can penetrate the airway down to alveolar space
  5微米以下的氣霧可達到肺泡
- 5~10 μm can go below glottis
  5~10微米的氣霧可達聲門以下
- >20 μm is too large to follow inhalation
  Surgical mask can be effective
  大於20微米就不易吸入

Size Classification

- >10 μm barely can reach LRT(lower respiratory tract)
  10微米以上的顆粒較難進入下呼吸道
- <10 μm can reach LRT : respirable particle
  10微米以下的顆粒才有機會達到下呼吸道形成空氣傳播
- Dental work mostly produce aerosols < 5 μm
  牙科工作大多產生5微米以下的氣霧

Aerosols in dental office

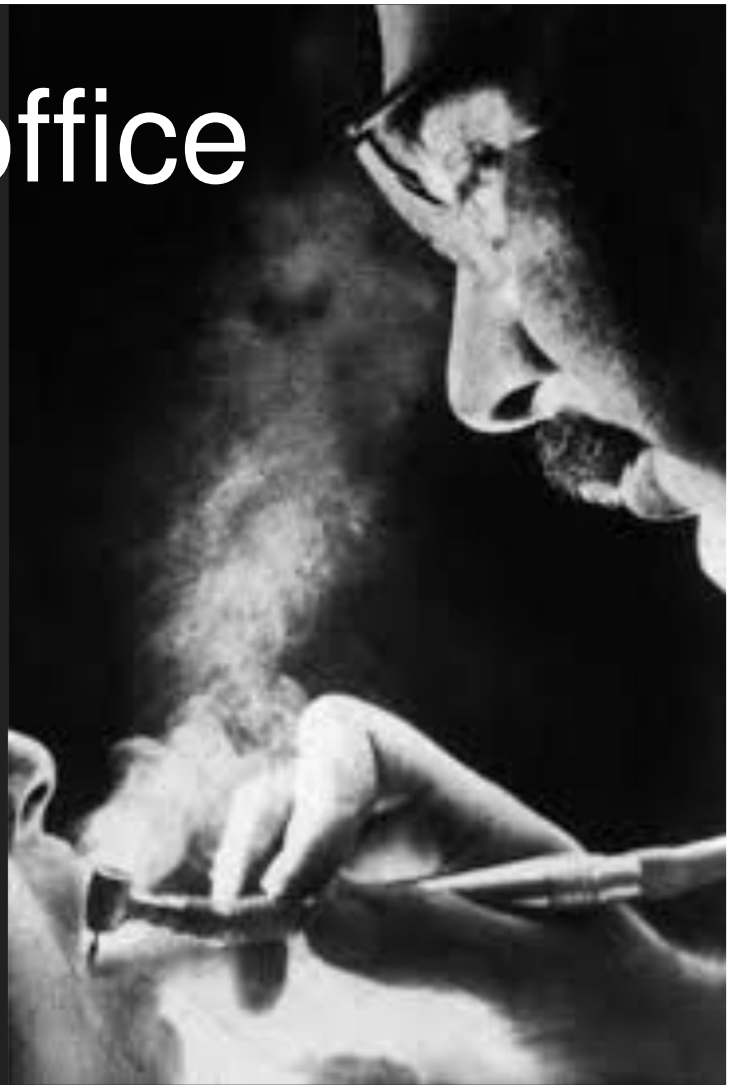
https://link.springer.com/article/10.1007%2Fs10661-007-9770-7

- Aerosol particle number and mass concentrations during individual dental procedures in real working conditions

  在實際牙科工作流程中測量氣霧微例種類分佈

- The dental procedures produced number concentrations of relatively small particles (<0.5 μm) that were much higher than concentrations produced for the relatively larger particles (>0.5 μm). （in 0.3~10μm）

  分析診間空氣中0.3~10μm的顆粒分佈中發現大多是小於0.5μm的顆粒



Aerosols in dental office

- Certain metallic trace elements concentrations were significantly elevated (>10 times)

  金屬粉塵的濃度高於戶外十倍以上

- Increased bacterial contamination, 1.5 times

  右圖有顏色是受測診間, 白色是對照休診的診間

  細菌量增加1.5倍

  休診後的診間仍存在各種氣霧微粒
  https://www.sciencedirect.com/science/article/abs/pii/S0013935114002849

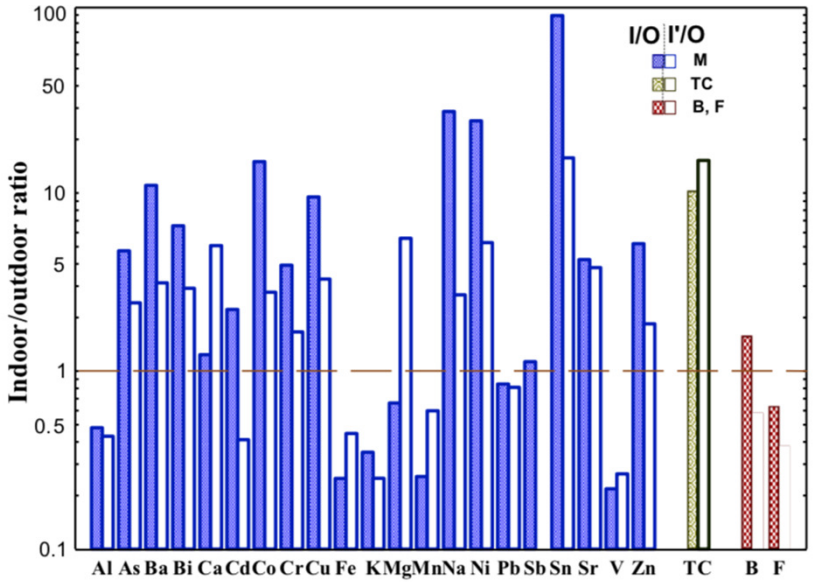
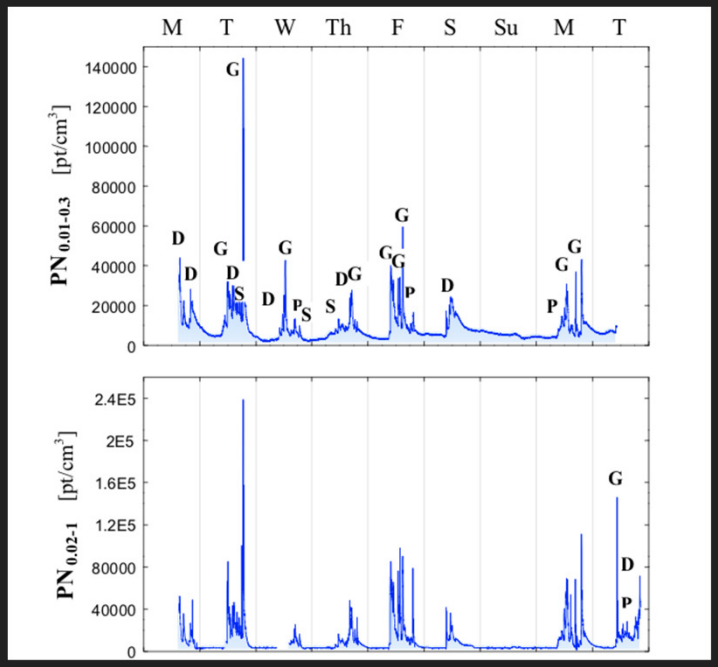


Fig. 2. Indoor to outdoor ratios of metallic elements (M) and total carbon (TC) concentrations in dust particles, and indoor to outdoor ratios of bacteria (B) and fungi (F) contamination levels. I/O and I′/O—indoor to outdoor ratios for the operating room and for the adjacent room respectively.

Aerosols in dental office



- Particle number Grinding > Drilling > Polishing > Scaling

  研磨產生最多的微粒數量, 洗牙相對較少

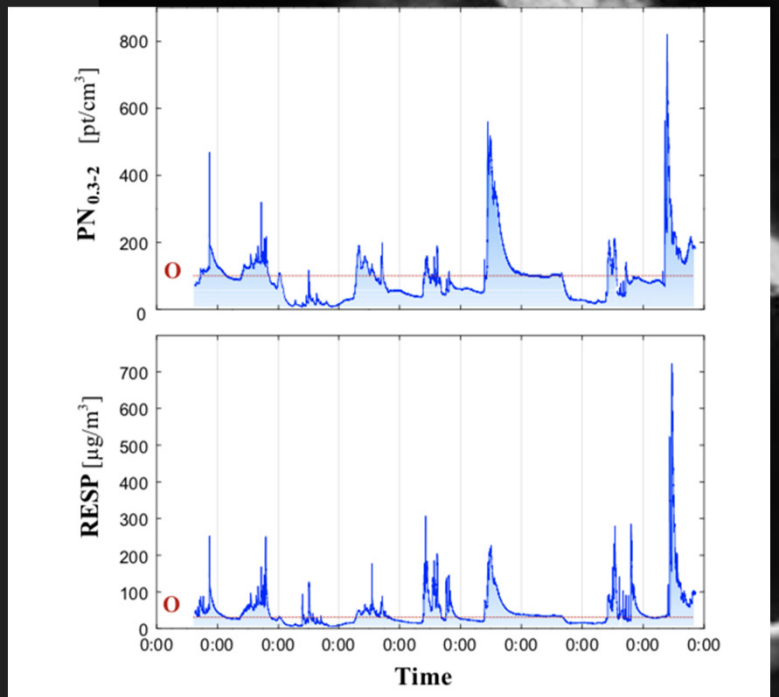


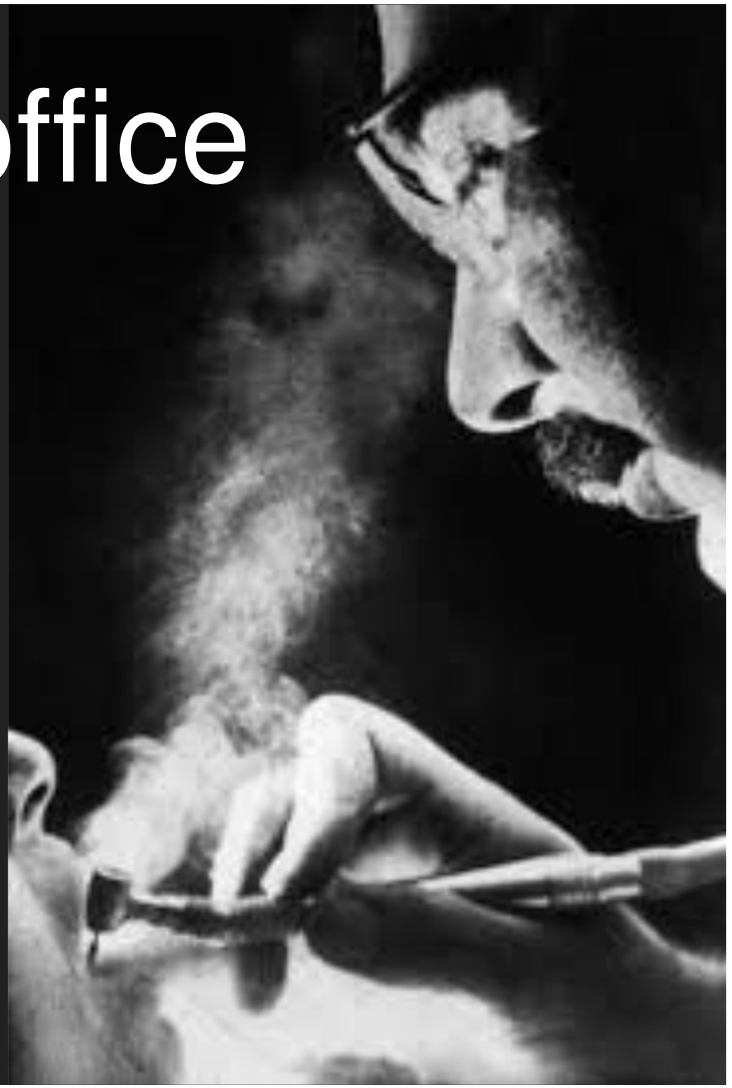
Fig. 1. Time series of the indoor particle number and mass concentrations in the dental office. PN—particle number; the indices represent the particle size fractions, RESP—respirable particles, O—average outdoor particle concentration, D—drilling, G—grinding, P—polishing, and S—scaling.

Aerosols in dental office

- Nanoparticle release from dental composites
- During extensive restorative/aesthetic treatments with nano-composite , such as veneering and total crown build-up of front teeth. Final contouring, finishing and polishing of the composite restorations.

實驗分析在前牙美學奈米樹脂的修復中, 在工作人員可呼吸到的範圍內, 修型與拋光會產生多少微粒

https://www.sciencedirect.com/science/article/abs/pii/S1742706113005096



Aerosols in dental office

a. external source (background)

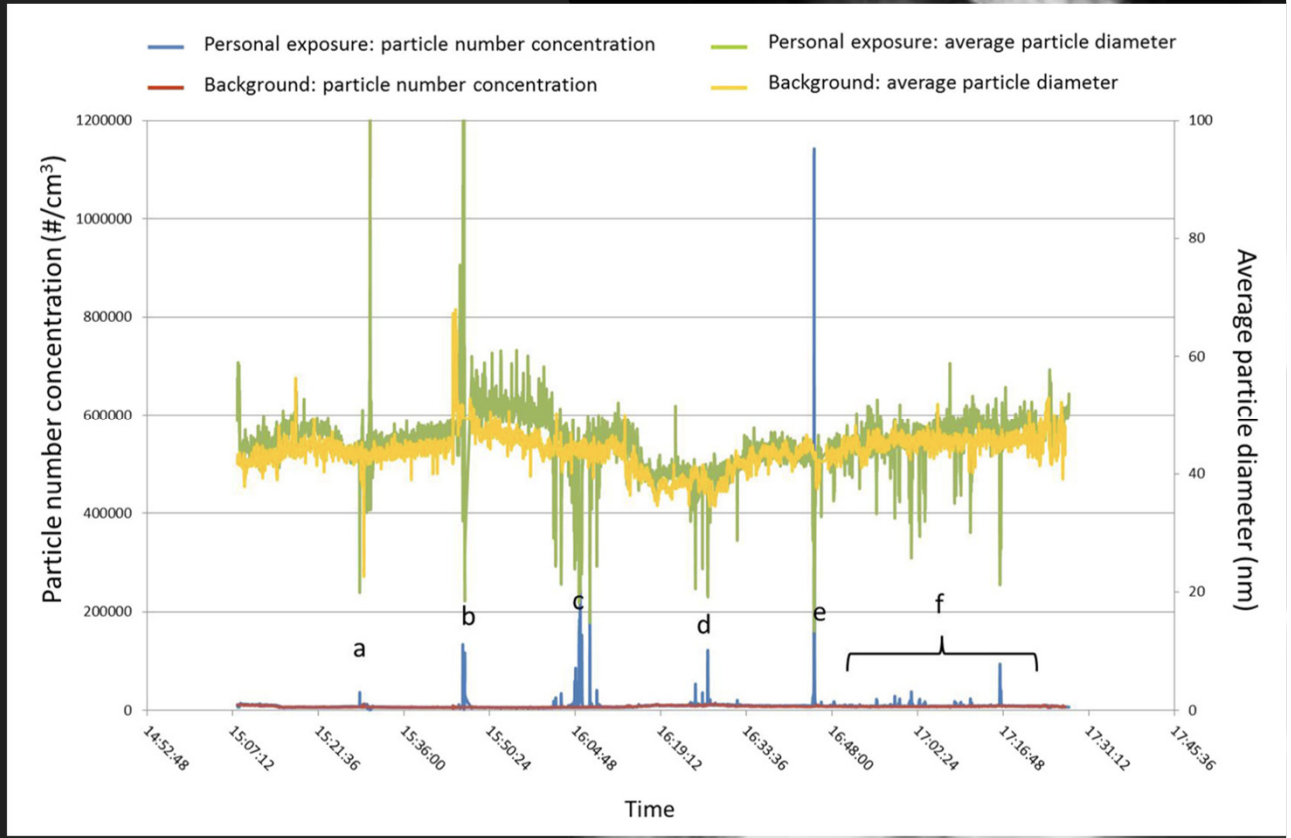
b. 11,12,13 rough diamond bur (100 μm)

c. 13 regular grid diamond bur and rough polishing disc

d. 12 regular grid diamond bur and rough polishing disc

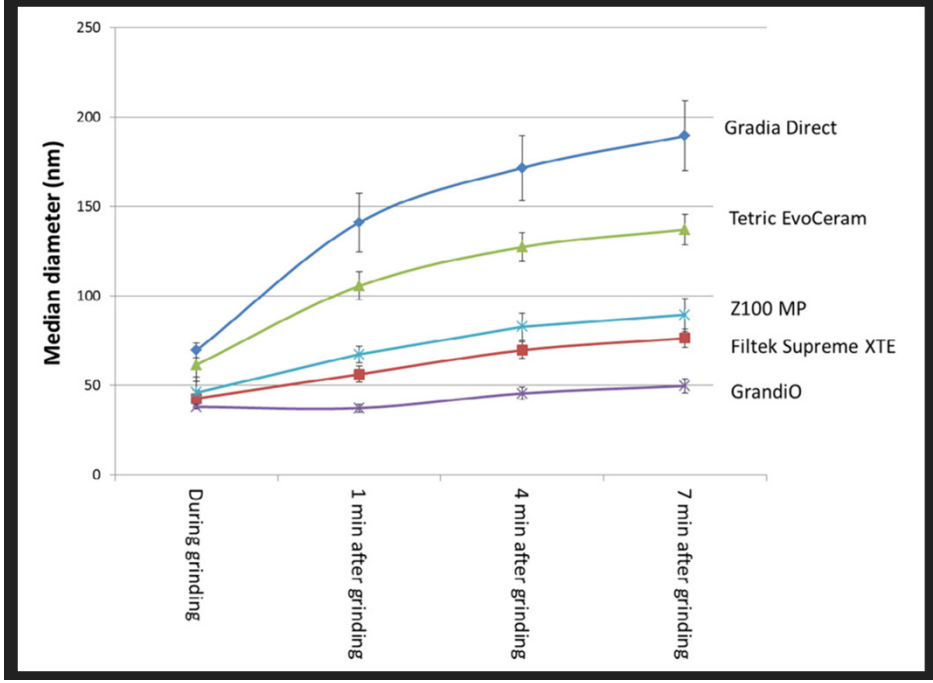
e. 11 rough polishing disc

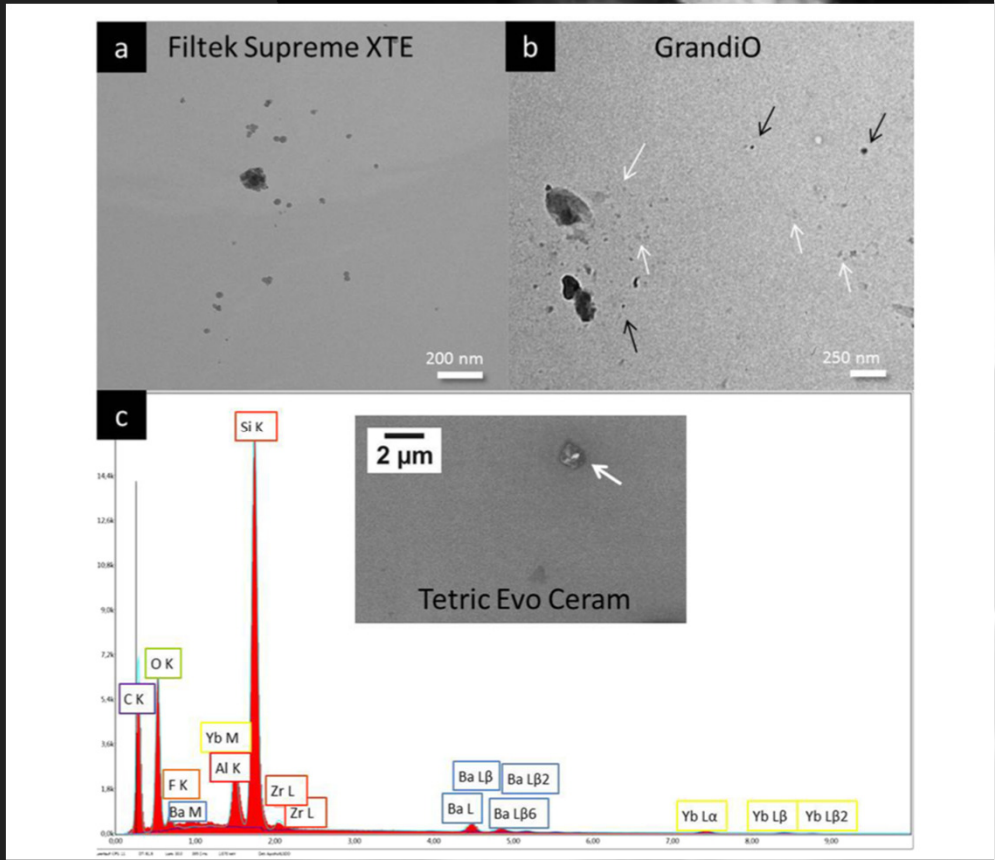
f. 11,12,13 fine diamond bur, rubber point fine polishing disc



Aerosols in dental office

- Nanoparticle coagulation
- During





Aerosols in dental office

- Higher composite aerosol concentration

  修型拋光時產生較高濃度粉塵不意外

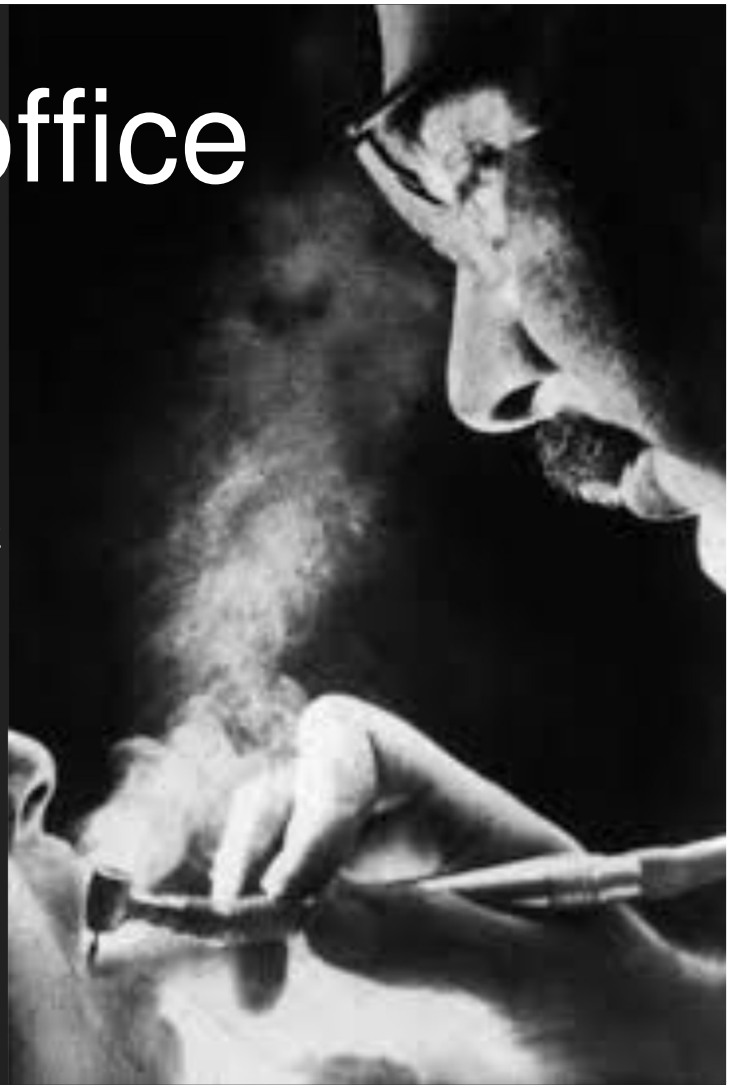
- Mostly Size < 60 nm (0.06μm) (can reach LRT)

  多數粉塵非常細微, 不易過濾, 吸入可直達下肺部, 後面實驗會提到這麼小的微粒上病毒的感染性可能較弱

- Several mins later, the particle size can coagulate to be 100~200 nm

  粉塵隨時間匯聚後變大, 病毒的感染力就較強, 也還是可以進入下呼吸道

- Immediate air purification即時吸塵並過濾空氣很重要



Virus in Aerosols

- Virus particles <200 nm are inhaled more readily down into the lower respiratory system than larger ones. 病毒氣霧更容易進入下呼吸道
- This study was to develop a model for assessing how infectious viruses might distribute in airborne particles using bacteriophage MS2 as a surrogate for human viruses.
  利用MS2這種單股RNA病毒(27.5~30nm)來分析病毒在氣霧中的分布模式
  https://www.tandfonline.com/doi/abs/10.1080/02786826.2019.1581917?journalCode=uast20

Virus in Aerosols

- 3 Spraying media containing viruses
- DI water (deionized water) 水中單純的分佈
- BEF (beef extract solution)模擬自然產生的氣霧
- AS (artificial saliva)模擬口水

https://www.tandfonline.com/doi/abs/10.1080/02786826.2019.1581917?journalCode=uast20

Virus in Aerosols

- The survivability of MS2 for AS is higher due to existence of mucin.

  病毒在口水中存活率較高

- Maximum survivability of 0.82 for 120nm particles. Survivability was very low at the size of 60 nm(smaller than mucin).

  口水中含有mucin導致提升病毒感染力, 但因為mucin體積較大, 60nm以下的微粒不含mucin所以感染力較差

- PFU plaque forming unit : infectious

  分析RNA成分可以知道病毒數量, 但是要能成為plaque-forming unit才表示該病毒具有感染能力
  https://www.tandfonline.com/doi/abs/10.1080/02786826.2019.1581917?journalCode=uast20

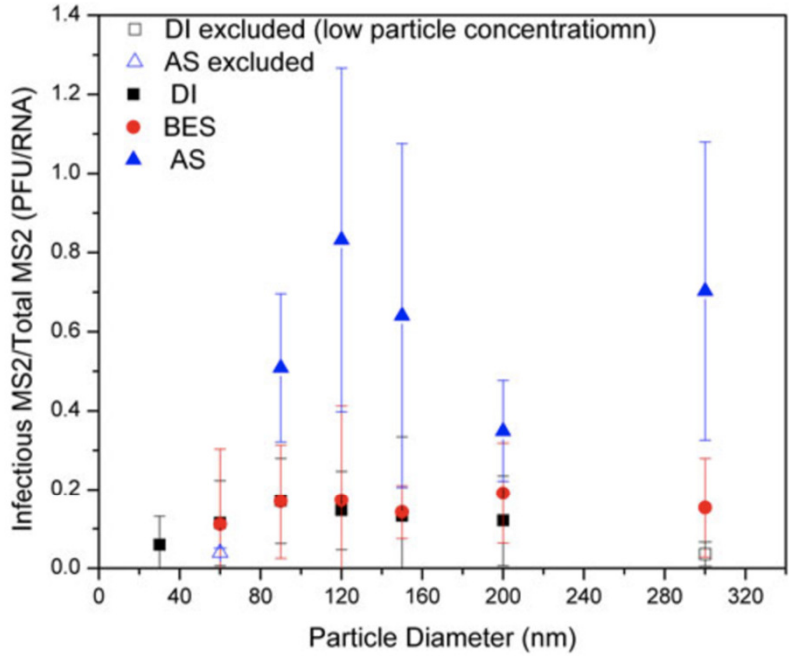


Figure 3. Survivability of MS2 as a function of particle diameter for different nebulization suspensions. Note: DI excluded and AS excluded are the data points that were not taken into analysis in the "Virus and genomic RNA equivalent per particle as a function of particle diameter and nebulization suspension" section. Data points of DI water for both infectious and total MS2 were triplicates, while for BES and AS, data points were repeated twice. Standard deviations were calculated and shown in the figures as error bars.

Coronavirus

- Coronaviruses are lipid-enveloped, single-stranded positive sense RNA viruses.

  單股RNA結構

- Severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle-East Respiratory Syndrome coronavirus (MERS-CoV)

  2003年中國發生的SARS, 2012年中東發生的MERS

- COVID-19 (SARS-COV2)

  2019年中國武漢肺炎

Coronavirus

- Potential airborne transmission

  已證實會存在空氣微粒中, 有可能會空氣傳播,

- Symptomatic patients tend to develop severe LRT infections rather than URT disease. Both of these aspects indicate that this is an airborne agent that has to penetrate directly into the LRT to preferentially replicate there before causing disease.

  SARS, MERS, COVID-19的臨床表徵, 以下呼吸道感染為主，因此被懷疑可能是空氣傳播

Coronavirus

- MERS-CoV ：absence of expression of specific receptor used by the virus in the cells of the human URT. The human URT would seem little or non-permissive for MERS-CoV replication, indicating that infection may result from the penetration into the LRT via direct inhalation of droplet nuclei particles.

  其中有研究證實上呼吸道缺乏MERS-COV受體, 病毒必須直接進入下呼吸道感染, 因此高度懷疑其空氣傳染性

  https://jvi.asm.org/content/90/9/4838

Coronavirus

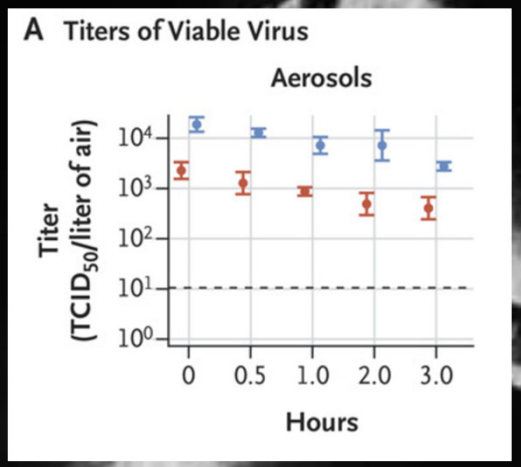
- SARS-COV-1 (blue) vs SARS-COV-2 (red) in aerosols (< 5 μm)
- Both remained viable in aerosols throughout the duration of our experiment (3 hours)

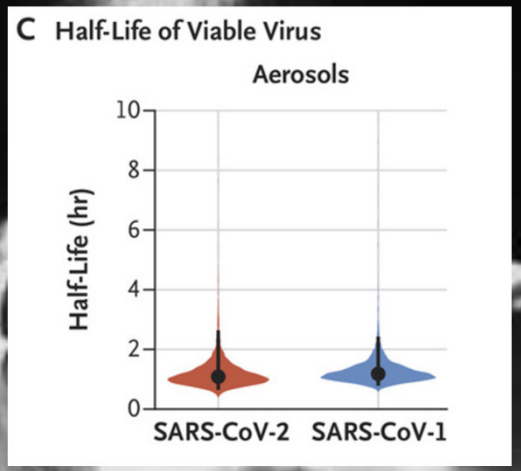
  都可以在空氣中至少存在三個小時

- The half-lives of both viruses were similar in aerosols, with median estimates of approximately 1.1 to 1.2 hours (95% credible intervals of 0.64 to 2.64 for SARS-CoV-2 and 0.78 to 2.43 for SARS-CoV-1)

  SARS-COV兩種病毒在空氣中半衰期約1.1~1.2小時

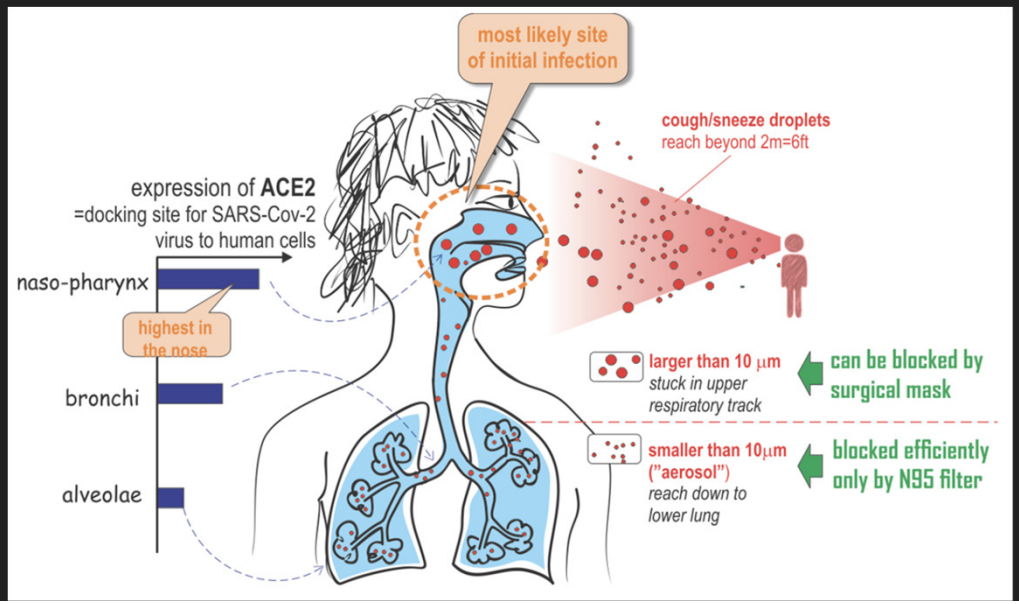
  https://www.nejm.org/doi/full/10.1056/NEJMc2004973

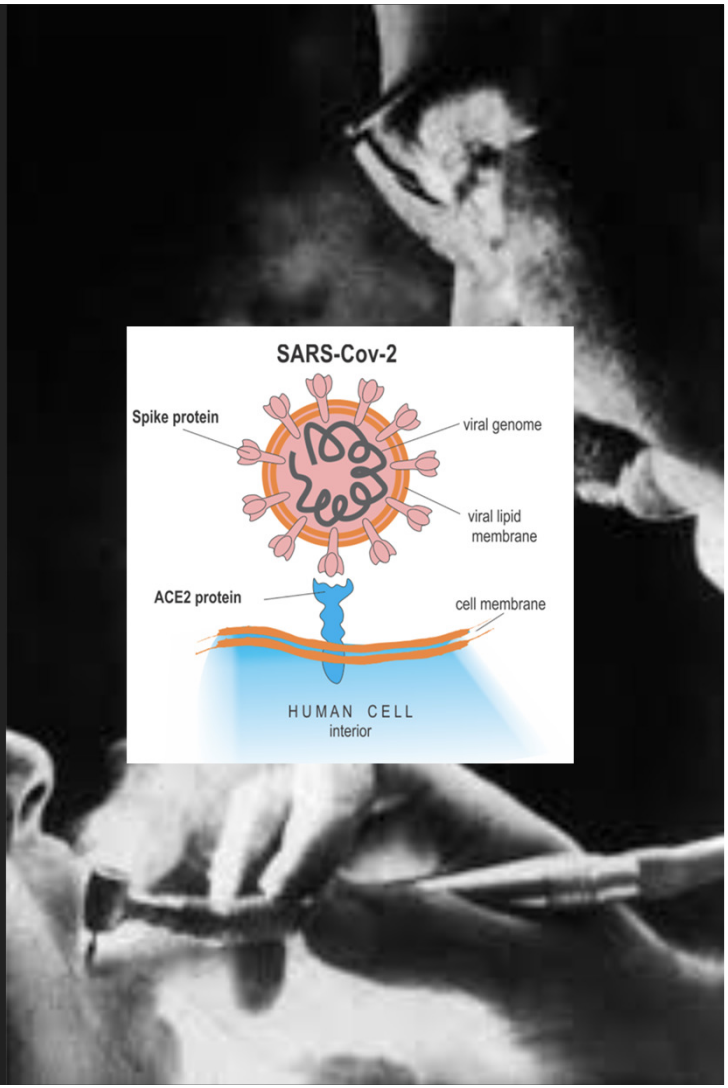




Coronavirus

- Binding affinity : SARS-COV-2 > SARS-COV-1
  https://www.medicalnewstoday.com/articles/why-does-sars-cov-2-spread-so-easily#Spike-protein-on-the-new-coronavirus
- SARS-Cov-2 virus, surface spike protein S is the ***key*** to dock on host cell with ACE2 protein.





Protective Strategy

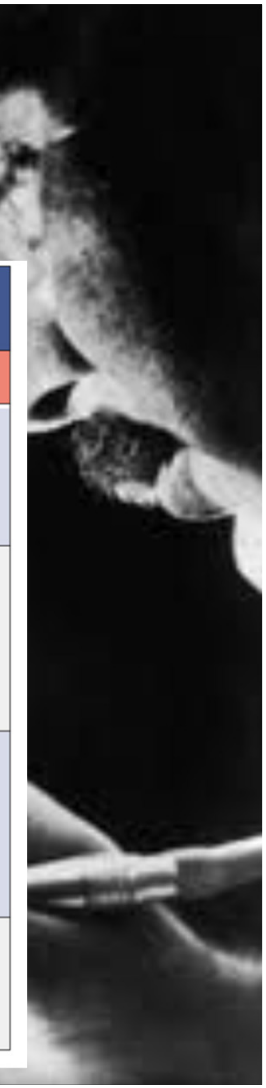
- Screening for patients and employees
  必要時14天居家觀察
- TOCC
  旅遊史（Travel history）職業別(Occupation) 接觸史（Contact history）是否群聚(Cluster) 必要時轉診或改約
- Signs and symptom
  感冒症狀, 採階段性治療, 減少飛沫接觸, 必要時轉診改約, 改約14天追蹤是否就醫並恢復, 懷疑流感且三天克流感無效應進一步檢測
- Masks for patients
  病患配戴口罩, 開始治療才卸下
- Hands and counter disinfection
  前檯做好消毒清潔 做好手部衛生減少接觸感染

Protective Strategy

- Mouth rinse 0.12~2% CHX for 1 mins
  減少口內細菌, 產生的氣霧飛沫中細菌也會減少
- Flushing waterline
  加強清洗管線避免堵塞並消毒, 避免機器噴出的水氣有交叉感染風險
  管線堵塞也會導致吸唾效果變差
- Rubber Dam
  橡皮帳隔離
- HVE (high volume evacuator)
  強吸大口徑吸管(>8mm), 距離操作位置6~15mm吸除微小氣霧
- PPE (personal protective equipment)
  手套 口罩N95 護目鏡 面罩 頭帽 隔離衣

Protective Strategy

https://www.buffalofilter.com/files/6314/2904/0016/Aerosols_and_Splattter_in_Dentistry.pdf



METHODS OF REDUCING AIRBORNE CONTAMINATION.

DEVICE	ADVANTAGES	DISADVANTAGES
Barrier Protection—Masks, Gloves and Eye Protection	Part of "standard precautions," inexpensive	Masks will only filter out 60 to 95 percent of aerosols, subject to leakage if not well-fitted, do not protect when mask is removed after the procedure
Preprocedural Rinse With Antiseptic Mouthwash Such as Chlorhexidine	Reduces the bacterial count in the mouth, saliva and air; inexpensive on a per-patient basis	Tends to be most effective on free-floating organisms; it will not affect biofilm organisms such as plaque, subgingival organisms, blood from the operative site or organisms from the nasopharynx
High-Volume Evacuator	Will reduce the number of bacteria in the air and remove most of the material generated at the operative site such as bacteria, blood and viruses; inexpensive on a per-patient basis	When an assistant is not available, it is necessary to use a high-volume evacuator attached to the instrument or a "dry field" device; a small-bore saliva ejector is not an adequate substitute
High-Efficiency Particulate Air Room Filters and Ultraviolet Treatment of Ventilation System	Effective in reducing numbers of airborne organisms	Only effective once the organisms are already in the room's air, moderate to expensive, may require engineering changes to the ventilation system

Protective Strategy

- High Volume Evacuator
  我們常常都是拿來當作high power suction, 但建議是拿來作為感控去除飛沫
  口徑要8mm以上吸力要夠強, 口徑越大吸力要更大
- HVE can reduce 90% aerosols
  實驗中發現可以去除90%氣霧, 較細微的顆粒因為更輕所以也較容易被吸除, 較大的顆粒仍會四散飛濺, 加上吸氣有方向性, 搭配正確的方向方式使用才有足夠效果, 吸力的強弱也會大大影響實際效能
  教學影片：
  https://www.youtube.com/watch?v=n92FU_iCzCs
  https://www.youtube.com/watch?v=IMwKVmEPBYI

  - 個人臨床實測, 洗牙產生的aerosol最容易被吸掉, 距離五公分也ok。
    High Speed則要依循標準靠近6~15mm才有效(一到兩顆牙距離), 但無法完全去除, 受轉速與噴水量影響：轉速越快氣流越強大越難被吸掉, 多孔噴水降溫效果較好但也會產生更多更雜亂的水花,
    反而是陽春單孔出水的high speed不會產生過多aerosols。
- Other intraoral suction device
  像zoo或是Easyprep可能也會有減少aerosol的功能

Protective Strategy

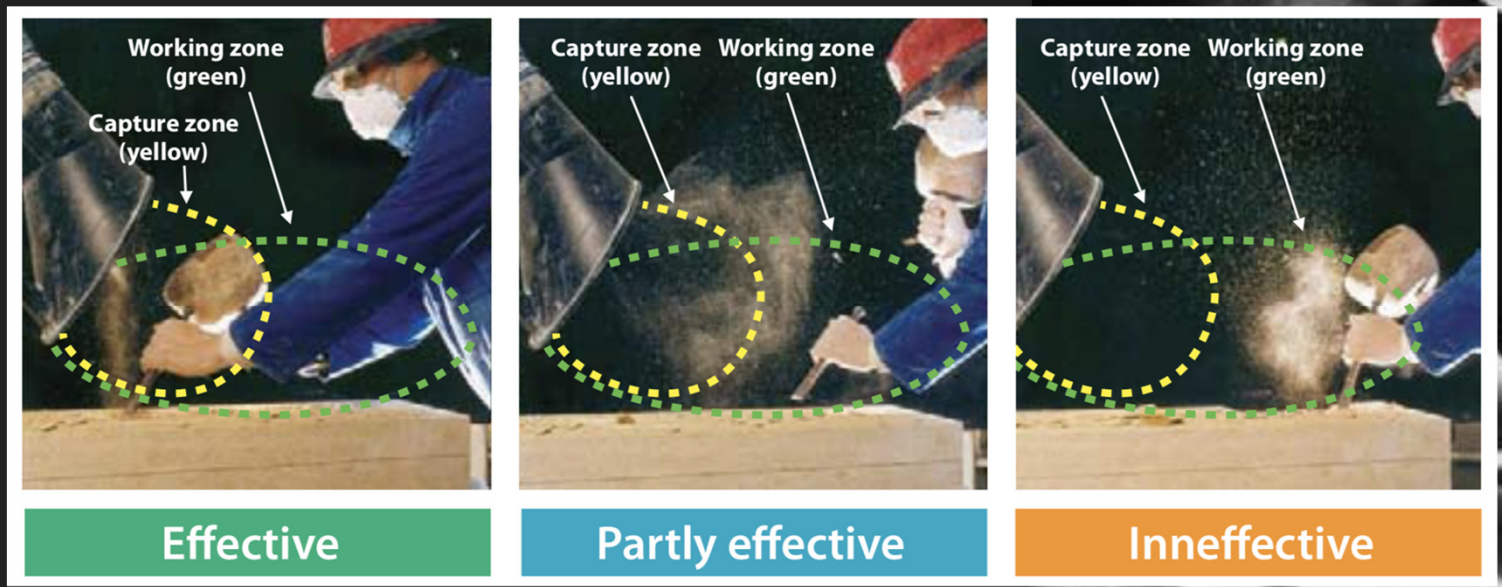
- Extra-oral Suction equipment HEPA口外吸塵器
  Powerful but noisy
  具有大開口及強力的吸力，比HVE更有效率地吸除大範圍粉塵飛沫
  個人實測的韓國機型具有12段強度, 距離口腔15公分操作：
  1段最弱的強度也可以應付洗牙
  使用高速手機6段的強度已經很足夠, 3段還ok, 但2段以下較不足
  因為開口大吸力也要更大因此很吵, 3段以上都聽不太到診所背景音樂,
  與病患溝通困難, 開太強會傷害聽力, 可用低吸力並搭配HVE使用
  風險高時使用強吸力, 建議搭配耳塞使用

  - 日本製口外吸塵器的進氣量為180m^3/h, 而較安靜的家用吸塵器大約為40m^3/h 產生噪音約60分貝, 而且家用吸塵器多為乾式吸塵, 除了HEPA濾網不建議接觸水氣, 重點是內部電路並不防水可能有故障風險, 感染物也無法有效清除或是安全替換濾材, 累積溼氣也會造成發霉發臭。

  - 使用完最好能像診所管線一樣可以消毒殺菌

Protective Strategy

- Hood near the emission point, aerosol can be highly energised. 距離很重要



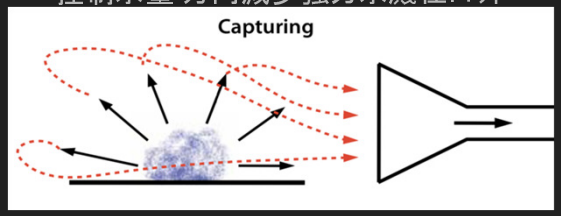
Protective Strategy

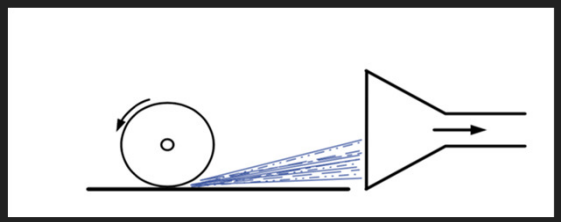
- Receiving and capturing:
  distance, direction and volume of water and air

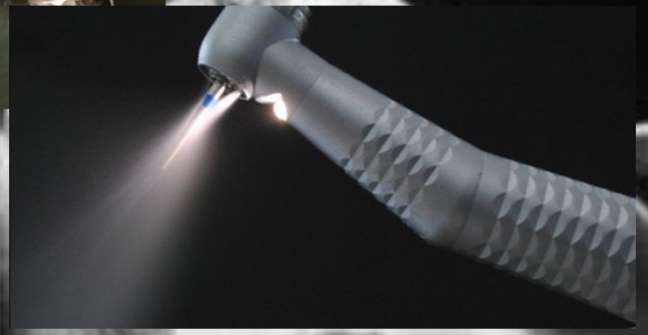
  吸塵裝置的距離和強度要足以吸收全部的污染源,
  另外也要考慮機具的方向性, 在牙科來說就是：

  高速手機的出水口 風量 水量
  高速手機的轉速和轉向
  Bur粗細與鎖車牙齒部位型態

  控制水量 方向減少強力水濺往口外

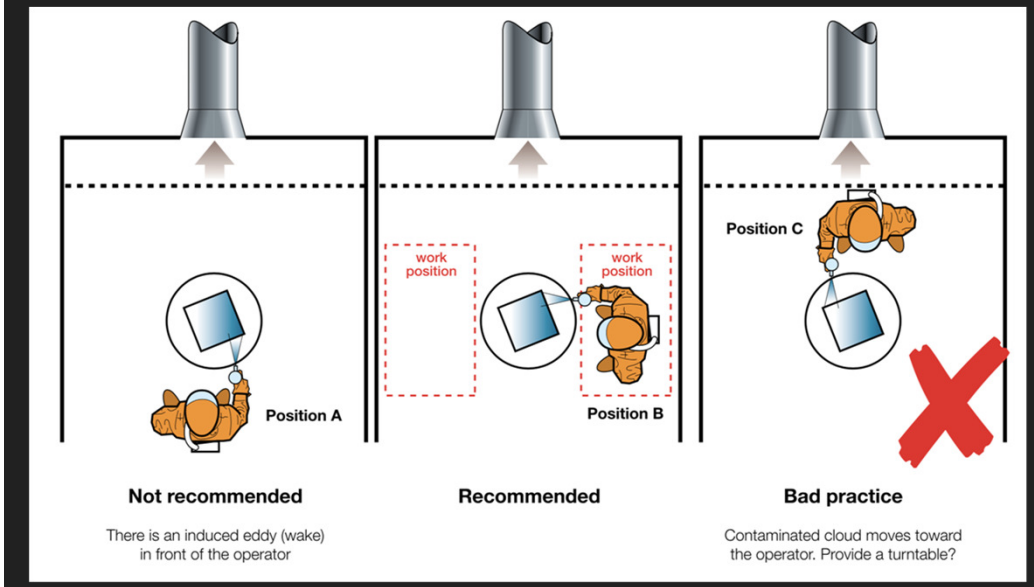


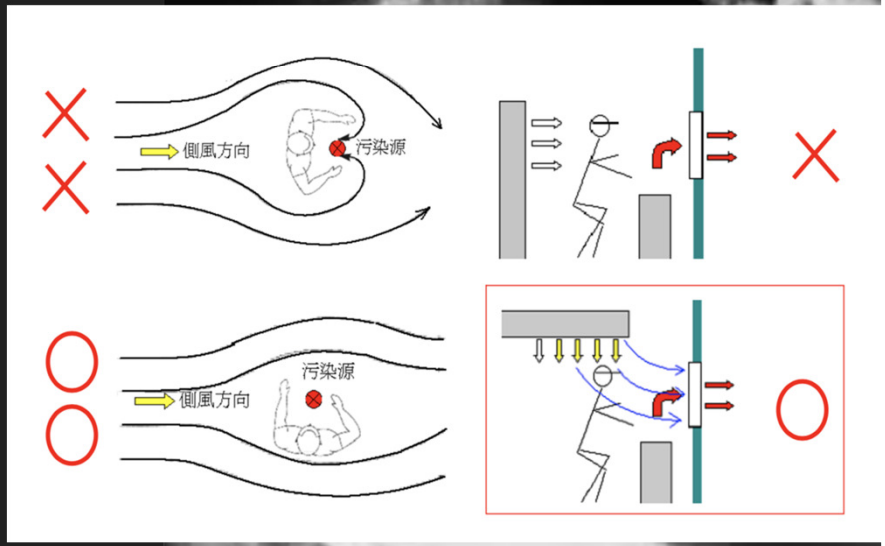




Protective Strategy

- Ventilation
  Proper air flow to prevent contamination.
  Reduce the concentration





Protective Strategy

- PPE levels 防護裝備等級
  因為SARS-COV可能會空氣傳播及接觸傳播, 加上並未完全了解, 因此呼吸道與眼睛的防護都很重要

- Confirmed or highly suspects patients:
  PPE Level B or C: high respiratory protection
  確診或高度懷疑感染病患, 在PPE等級中著重呼吸道防護
  - C：N95半臉或全臉的空氣濾鏡裝置, 搭配護目鏡或面罩
  - B：正壓呼吸器 self-contained breathing apparatus (SCBA)
  - 都要搭配全身防護衣褲, 鞋子和手套
- Reduce infection risk降低感染風險機率
  全球疫情爆發, 若社區感染爆發理論上要懷疑就診病患都可能帶原來做防護, 但不僅資源不夠, 成本也非常高, 先篩選適當病人再選擇不同程度的PPE

- Optimize the availability of PPE 以下WHO連結供參考
  https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE_use-2020.2-eng.pdf

Protective Strategy

- Face mask fit test
  任何等級的口罩都要密合才能達到效果
- Qualitative fit test
  定性測試 利用嗅覺來偵測是否會聞到口罩外試驗用物質

  Quantitative fit test
  定量測試 偵測微粒在口罩內外的比例

  以上兩者是比較專業的測試 還要考量佩戴者運動下或長期臉型變化是否影
  密合度 需要定期做測試
- Positive pressure
  正壓測試 吹氣測試氣流是否從正確位置排出

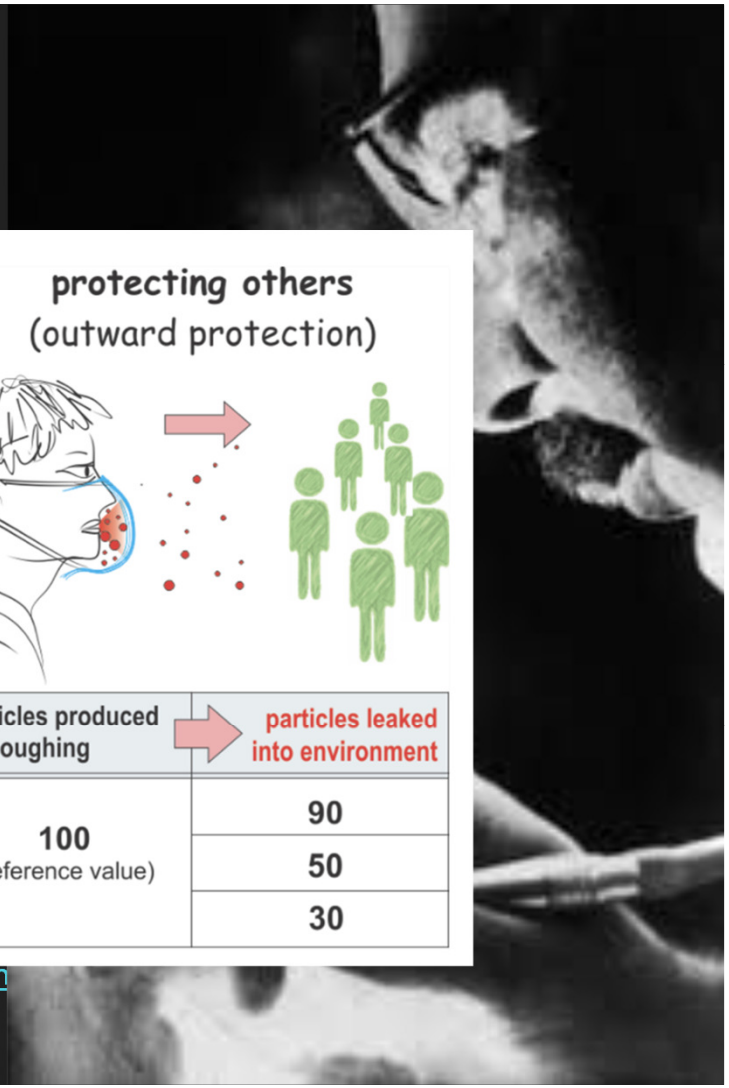
  Negative pressure
  負壓測試 吸氣測試氣流是否從正確位置吸入

  若有從鼻樑或側邊溢出要調整壓條或綁帶 每次配戴都要測試

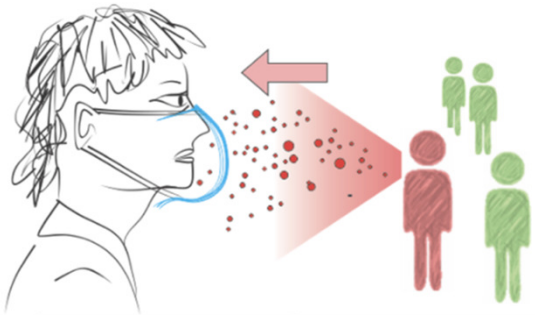
https://www.xamax.co.uk/blog/how-to-respirator-face-fit-test-guide.html
https://www.hse.gov.uk/pubns/disposable-respirator.pdf

7 Before entering the workplace, a user seal check should be carried out. This is done by placing your hands over the filter material and breathing in. The mask should suck down onto your face when you breathe in sharply. You should hold your breath for ten seconds and the disposable respirator should not loosen. If it does, you should readjust and repeat.

Protective Strategy



protecting yourself
(inward protection)



	particles leaked through mask	particles produced in environment
TEA CLOTH (home made)	33	100 (reference value)
SURGICAL MASK	25	
FFP2 (=N95 equivalent)	1	

protecting others
(outward protection)

particles produced by coughing	particles leaked into environment
100 (reference value)	90
	50
	30

https://medium.com/@Cancerwarrior/covid-19-why-we-should-all-wear-masks-th
is-new-scientific-rationale-280e08ceee71

Working with loupes

- PPE like goggles or faceshield may interfere with high definition needed for precise dental work.
  防護裝置有時候會降低視野清晰度導致治療品質降低
- If the risk is high and safety counts first, please choose the highest possible PPE level with or without loupes.
  風險高時安全至上, 如果戴護物鏡可能只有較低倍外掛或頭戴式放大鏡可用。

Working with loupes

- The benefit of working with loupes:
  - Keep good distance (within 30 cm is the most contaminated zone according to aerosol spread)
    工作距離至少四十公分以上，越遠可能接觸的aerosol就越少。
  - Maintain good treatment quality
    沒有放大導致品質不良

- The priority is the patient screening and how the epidemic evolve, to evaluate the risk.
  從源頭降低接觸機率, 評估風險
- SCBA + loupes : highest standard
  正壓呼吸隔離裝置, 有的空間足夠容納放大鏡, 最高規格避免吸入感染風險

Thanks to Dr. Kido Chuang

Working with loupes

- Faceshield + loupes to lower the risk :
  - Cover frontal and both sides
  - Cover chin and forehead, or top
    面罩要能大範圍遮擋, 在HVE或吸塵器去掉大部分飛沫後進一步減少眼口鼻接觸飛沫風險
  - Shield material with high transparency and low reflection
    面罩清晰度要高 反光要少
- Moisture and fog on the loupes
  - Proper mask adaptation
  - Slow breathing to balance the temperature
    口罩上緣密封降低霧氣影響, 待溫度平衡, 若一開始溫差大需要擦拭掉水霧
- TTF : loupes Through The Faceshield
  Cut the shield and seal the gap, best clarity
  面罩挖洞伸出放大鏡可以有最好的清晰度, 露出的間隙要有適當阻隔,
  使用後也要仔細消毒

Working with loupes

- Keep all the PPE while talking to patients after the treatment
  治療完跟病人講解也要戴好面罩, 不要正對病人
  别忘記身為風險工作者除了保護自己也要了解自身疾病的風險保護病人
- Remember the aerosol can spread in the air 30 mins after scaling.
  洗牙完細微的氣霧微粒可在空氣中傳播, 尤其是30分鐘內
  有適當的通風可以加速排出降低濃度
- Speaking can transmit aerosols 說話也有傳播風險

https://medium.com/@Cancerwarrior/covid-19-why-we-should-all-wear-masks-there-is-new-scientific-rationale-280e08ceee71

- Ventilation and Air purification
  通風和淨化空氣

Working with loupes

- Disposable gown
  有拋棄式隔離衣較佳, 減少接觸感染
- Disposable oversleeve and gloves to cover the most contaminated area
  若缺乏拋棄式隔離衣, 可在易感染部位用拋棄式袖套延伸手套部位防護, 甚至拋棄式圍巾
- Discard or disinfect the PPE
  每個病人結束後置換可拋棄部分並消毒重複使用部分
- Disinfect the loupes with proper lens disinfectant
  放大鏡消毒, 用專用消毒清潔劑, 尤其是放大鏡露出狀態
  減少或避免掛胸口, 因胸口也是飛沫污染部位

Risk assessment

- Infection rate in community社區感染有無或感染比例 最為關鍵
- Self quarantine compliance rate in community
  具接觸史或症狀乖乖隔離比例
- Suspect or Carrier without S/S篩選後的病人已感染機率
  如冰島研究感染無症狀者達50%, 長期要考慮復原仍能傳染者比例
- Treatment and selective Tx plan產生aerosol的量多寡, 是否分次觀察
  如使用高速手機或研磨, 若病人有輕微感冒是否先處理急症即可,
- Aerosol evacuation使用HVE等吸氣霧裝置, 若風險較高搭配使用吸塵器
- PPE layers面罩隔離, 護目鏡隔離, 口罩過濾等級, 降低吸入機率
- Infection control嚴格感染控制減少接觸交叉感染
- Air ventilation and purification空氣淨化降低aerosol濃度

做好風險管理, 把上述每項感染機率相乘, 很多無法控制的公眾場合反而更危險...

All information shared is gathered from resources available online and literature available. I give credit to all the researchers helping us understand more about dental aerosols.

Please feel free to share this document online to help fight against COVID-19 and protect ourselves while providing dental care to people.

If there are any questions about the content of the material please feel free to contact me.

Thank you.

Dental Aerosol

Now you can “see” the aerosols
In your mind.
Well prepared...

Etjsteen Wu

- Dentist
- Taiwan
- 2020