UNIVERSITÉ CÔTE D'AZUR

FORMATION CIPE E-CLASS N°8

TRANSMISSION PAR VOIE AERIENNE SARS-COV-2 (COVID-19)

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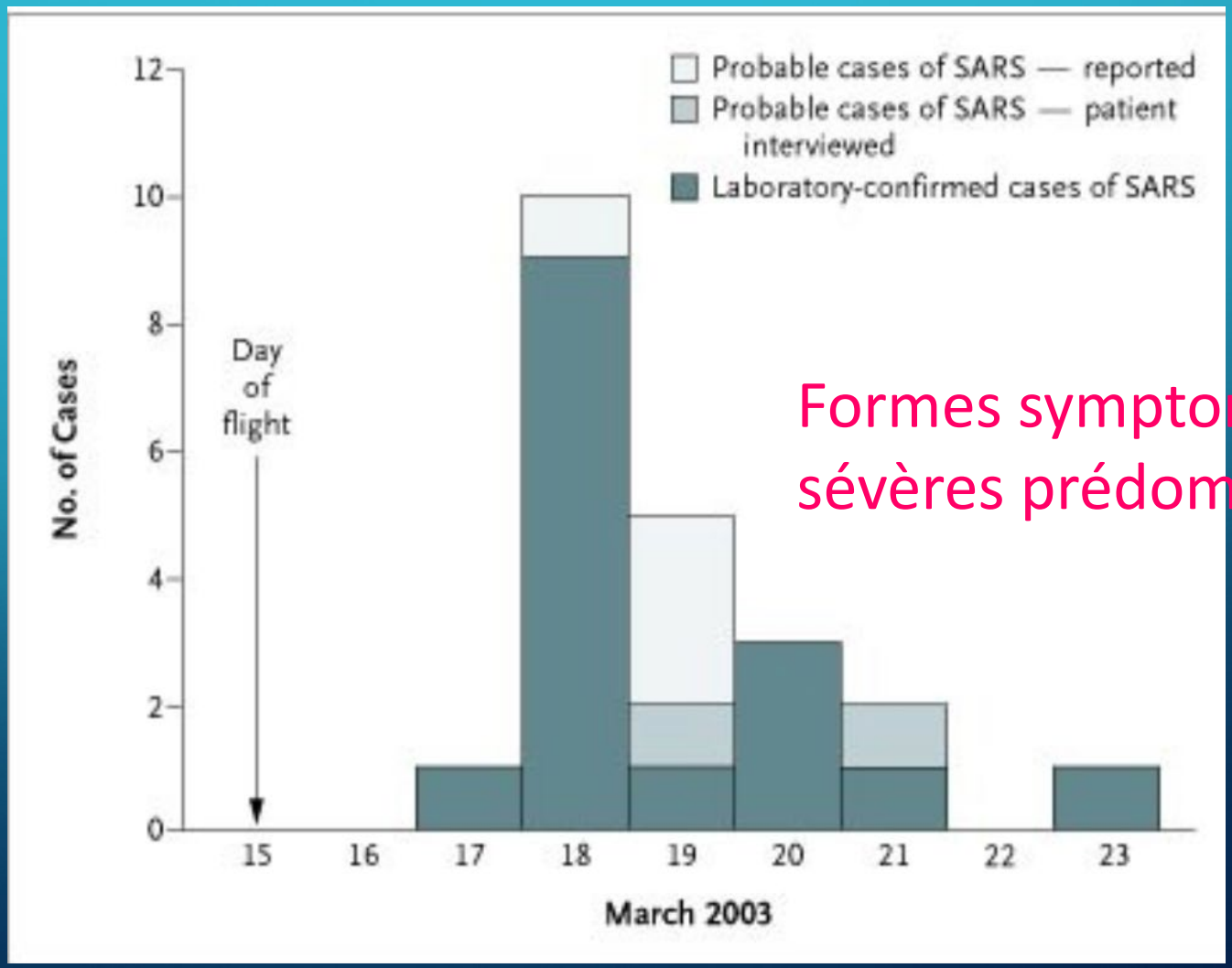
QUEL MODE DE TRANSMISSION?

- Période très courte de virus émergent respiratoire (proche SARS-CoV-1 Air+contact)
- Suivi d'une période pré confinement sur la non utilité du masque pour le grand public (pénurie masques?), le contact-tracing ciblé sur sujets symptomatiques (pénurie tests?) et la transmission à courte distance type gouttelette (< 1m, masques y compris en tissu ..) le masque FFP2 réservé aux situations à haut risque de production aérosols (stocks limités?)
- En fait très tôt évidences du rôle des aérosols

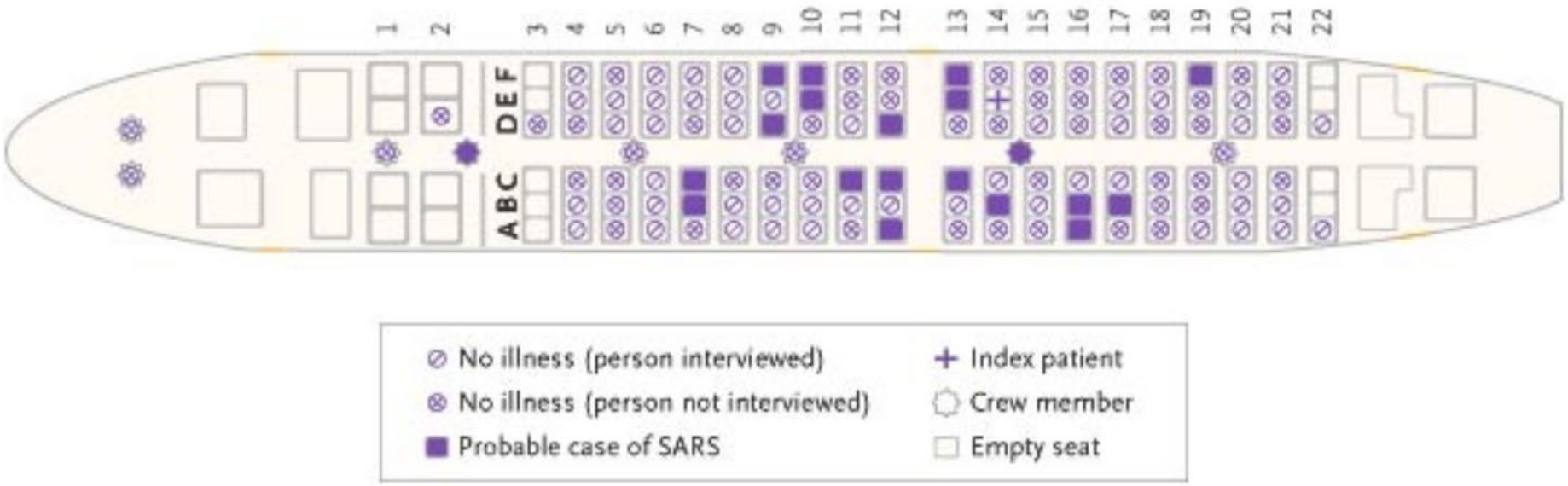
TRANSMISSION DE SARS DANS UN AVION
(SJ OLSEN, NEJM, 2003

https://www.nejm.org/doi/full/10.1056/NEJMoa031349

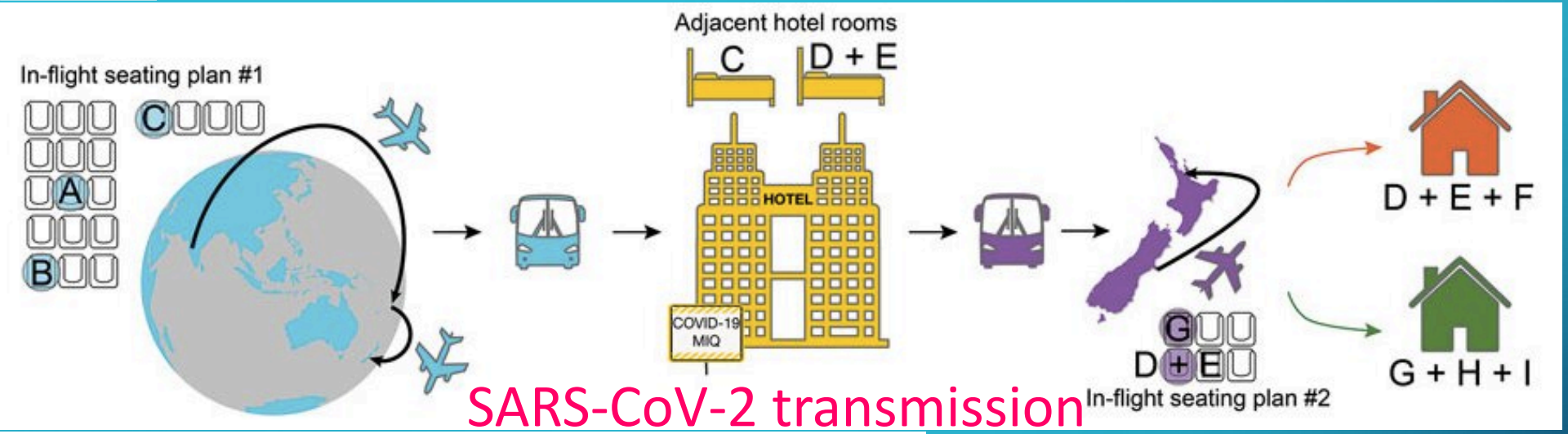


Formes symptomatiques sévères prédominantes

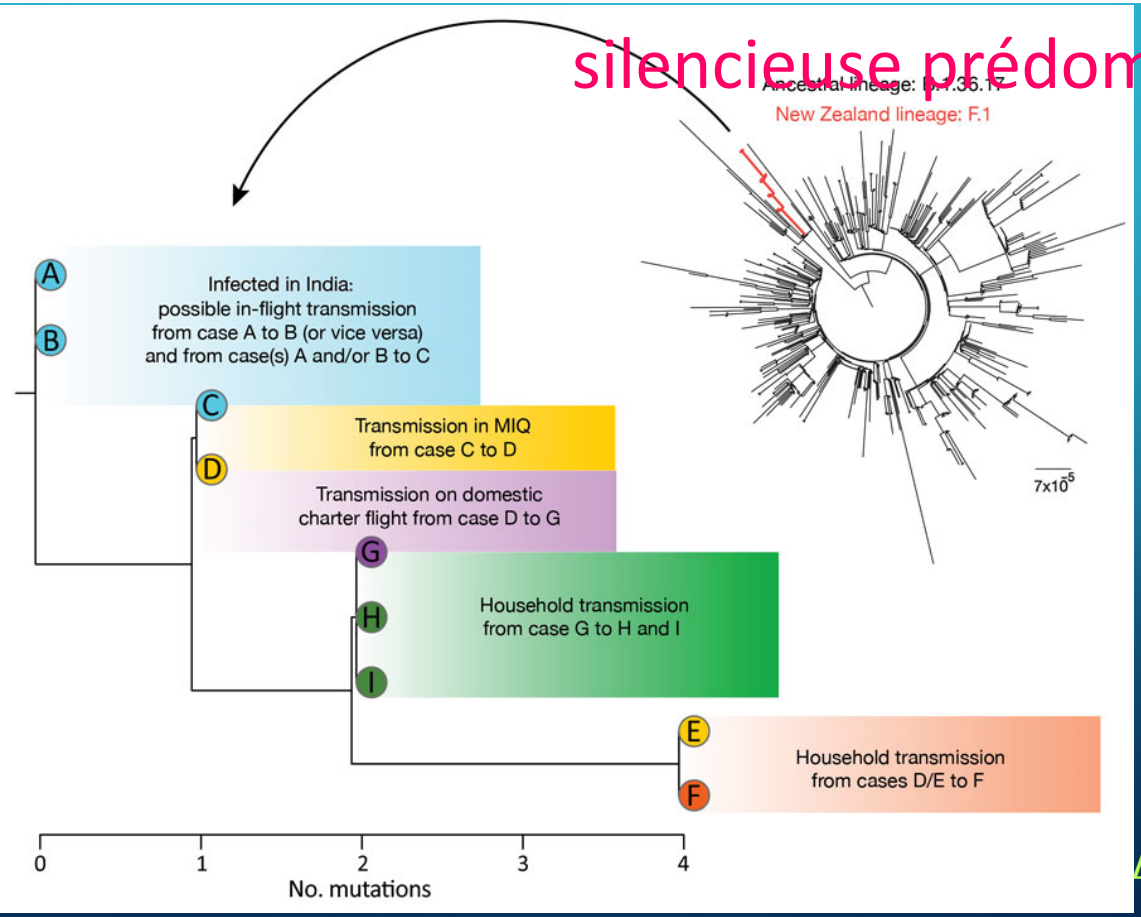
TRANSMISSION DE SARS DANS UN AVION
(SJ OLSEN, NEJM, 2003;349:2416-22) © N ENGL J MED



Autres exemples transmission aériennes décrits (ascenceurs, nosocomiales..



SARS-CoV-2 transmission silencieuse prédominante

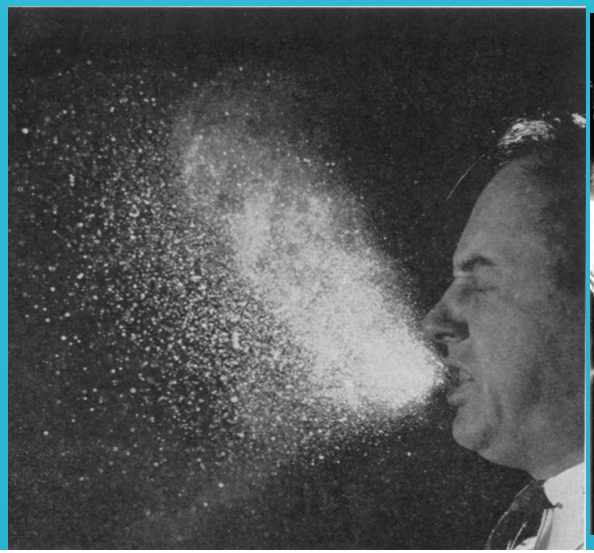


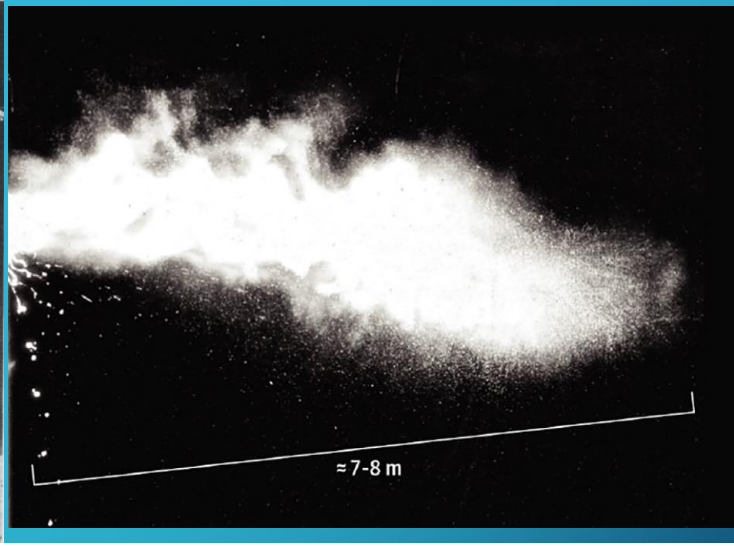
CHAINE DE CONTAMINATION ET TRANSMISSION PAR AEROSOLS PROBABLE

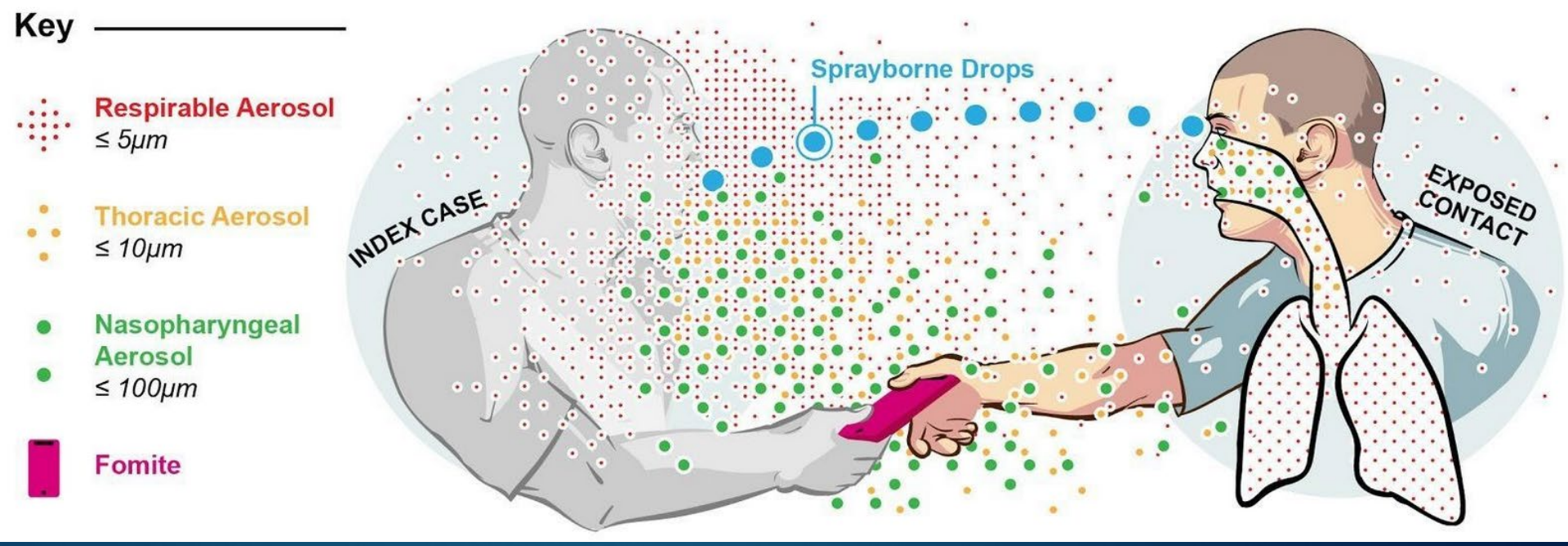
Eichler N, et al. Emerg Infect Dis. 2021 May

/www.bmj.com/content/373/bmj.n913

COVID-19 TRANSMISSION







https://docs.google.com/document/d/1fB5pysccOHvxphpTmCG_TGdytavMmc1cUumn8m0pwzo/edit

https://indoor-covid-safety.herokuapp.com/

Positive SARS-CoV-2 air and no-touch surface sampling studies in health care settingsa.

X. Sophie Zhang, and Caroline Duchaine Clin. Microbiol. Rev. 2020; doi:10.1128/CMR.00184-20

Study setting	Design	Proportion of positive samples	Strengths (+) and limitations (−)
Published studies with negative viral cultures			
Santarpia et al., 2020 (103) Nebraska, USA Low- and high-risk	13 pts in isolation units Air sampling: 50 liters/min for 15 min (750 liters) and personal air sampler (4 liters/min) on HCWs No-touch: air handling grates and window ledges	Air: 12/19 in rooms, 7/12 in hallway, 4/4 on personal sampler No-touch: 4/5 grates, 16/22 ledges	(+) Evaluation of long-range (e.g., hallway) and short-range (e.g., personal air sampler) (+) Sample positivity linked to onset of Sx (+) Viral loads measured (−) Unknown particle sizes (−) Sampler positions unknown or suboptimal (e.g., risk of contamination by particles resuspended from the floor)
Zhou et al., 2020 (104) ondon, UK Low- and high-risk (including ICU)	5 hospitals (including GW, ICU, emergency department) Air sampling: 3 or 4 samplers collecting 1 m^3 in pt, staff, and public areas	Air: 2/31 confirmed positive in cohort ward and acute admission unit; 14/31 suspected positive	(+) Viral loads measured (+) Sample positivity linked to ward type (GW>ICU) and distance from pt (−) Lack of clinical data on pts (−) Air sampling during AGPs (−) Unknown particle sizes (−) Unknown sampling flow rate and duration
Binder et al., 2020 (105) California, USA Assumed low-risk	20 hospitalized pts Air sampling: 3.5 liters/min for 4 h (840 liters) in in high- and low-risk areas	Air: 3/195 from 3 different pt rooms (particle sizes, <4 μm and >4 μm)	(+) Aerosol sizes and viral loads measured (−) Lack of clinical data and risk level (−) UV light disinfection (false negative) (−) 50% of pts at day 8 or more of infection
Published studies without viral cultures			
Chia et al., 2020 (193) Singapore Low- and high-risk (including ICU)	5 pts in AIIRs Air sampling: in 3 GW rooms, 6 samplers at 3.5 liters/min for 4 h (5,040 liters) No-touch: exhaust vents in 4 GW rooms and 1 ICU room	Air: 2/3 (particle sizes, >4 μm and 1–4 μm) No-touch: 3/5	(+) Aerosol sizes and viral loads measured (+) Sample positivity linked to Sx (4/5 pts symptomatic on day of sampling), onset of illness (wk 1) and viral load (+) No AGPs during sampling
Liu et al., 2020 (194) Wuhan, China Low- and high-risk (including ICU)	Tertiary hospital (severe cases) and make-shift center (mild cases) Air sampling: various sampling duration at 5 liters/min in pt, staff and public areas No-touch: ICU room corner	Air: 19/33 (particle sizes, 0.25–1.0 μm and >2.5 μm) No-touch: 2/2	(+) Aerosol sizes and viral loads measured (+) Sample positivity linked to ventilation (e.g., high loads in mobile toilet) (−) Lack of clinical data on individual pts (−) Floor sampling (risk of contamination by resuspension of settled particles)
Ding et al., 2020 (152) Nanjing, China Unknown risk level	10 pts in COVID-19 hospital Air sampling: various devices from 10 liters/min for 30 min to 500 liters/min for 20 min; EBC and exhaled air samples No-touch: toilet and roof exhausts	Air: 1/46 in corridor; 0/2 EBC, 0/2 exhaled air No-touch: 1/1 toilet, 0/5 roof	(+) Detailed description of pt data and environment (including air flows) (+) Specific data on exhaled breath (+) Viral loads measured (+) Hypothesis on fecal origin of aerosols (−) Unknown particle size
Guo et al., 2020 (144) Wuhan, China Low- and high-risk (including ICU)	15 ICU pts and 24 GW pts Air sampling: 300 liters/min for 30 min (9,000 liters) near and far from pts (e.g., corridor) No-touch: air outlets	Air: 14/40 in ICU, 2/16 in GW No-touch: 8/12 in ICU, 1/12 in GW	(+) Viral loads measured (+) Sample positivity inversely correlated with distance from pt: positive up to 4 m away (−) Unknown particle sizes
Ong et al., 2020 (146) Singapore Assumed low-risk	3 symptomatic pts in AIIRS Air sampling: 5 liters/min for 4 h and 6 m^3/h for 15 min (1,200–1,500 liters) No-touch: air outlet fan	Air: 0/10 No-touch: 2/3	(+) Sample positivity correlated with clinical data and timing of cleaning (+) Viral loads measured (−) Air outlet fan close enough to coughing pt to be contaminated by droplets (195)
Ma et al., 2020 (153) Beijing, China Low- and high-risk (including ICU)	Hospital and quarantine hotel Air sampling: 15 to 400 liters/min for 40 min (600–16,000 liters) Breath sampling from 49 pts: 300–500 μl of EBC No-touch: ventilation duct	Air: 1/26 in unventilated hotel toilet EBC: 14/52 No-touch: 1/1	(+) Specific data on exhaled breath (+) Viral loads measured (+) Sample positivity linked to disease stage (−) Possible saliva contamination of EBC (196) (−) Possible contamination of ventilation duct (located beneath a pt bed) (−) Unknown particle sizes
Razzini et al., 2020 (197) Milan, Italy High-risk (ICU)	3 pts in a COVID-19 isolation ward Air sampling: 50 liters/min for 40 min (2 m^3) in contaminated (pt) areas, semicontaminated and clean (staff) areas	5 samples total: 100% positive in contaminated areas, 0% in semicontaminated and clean areas	(+) Viral loads measured (−) Unknown particle sizes (−) Lack of clinical data on pts (−) Unspecified no. of samples per area (−) High-risk setting only (2/3 pts intubated)
Kenarkoohi et al., 2020 (198) Iran Low- and high-risk (including ICU)	10–30 pts in different areas of a COVID-19 hospital Air sampling: 12 liters/min for 3 h (2,160 liters) in ICU, GW, and low-risk areas	Air: 2/14 (in 2 ICU wards with 10 severely ill pts each)	(+) Viral loads measured (+) Detailed information on environment, pts and interventions (−) PM (particulate matter) sizes measured, but not viral aerosol sizes
Mouchtouri et al., 2020 (199) Greece Low- and high-risk	Hospital AIIR, long-term care isolation wards, nursing home Air sampling: 50 liters/min for 10 min (500 liters)	Air: 1/12 (maskless hospitalized pt) No-touch: 1 (nursing home A/C filter)	(+) Inclusion of long-term care facilities (−) Unknown particle concentration and sizes (−) Unknown total no. of pts and lack of clinical data on pts
Unpublished studies with positive viral cultures			
Santarpia et al., 2020 (preprint) (106) Nebraska, USA Unknown risk level	Air sampling: 6 samplers at 3.5 liters/min for 30 min (105 liters)	Air: 6/6 (particle size, <1 μm)	(+) Aerosol sizes and viral loads measured (+) Viral protein and RNA detection from culture (−) Absence of C_T values (−) $TCID_{50}$ value obtained in culture applied to initial air sample
Lednicky et al. (2020) (preprint) (107) Florida, USA Low-risk	2 pts in a designated COVID-19 ward Air sampling: 3 h	Air: 4/4	(+) Water vapor condensation sampling (+) Matching virus sequence with pt swab (−) Lack of symptom data on pts (−) Unknown flow rate of air sampling (−) Implausible viral loads (−) Unknown particle sizes

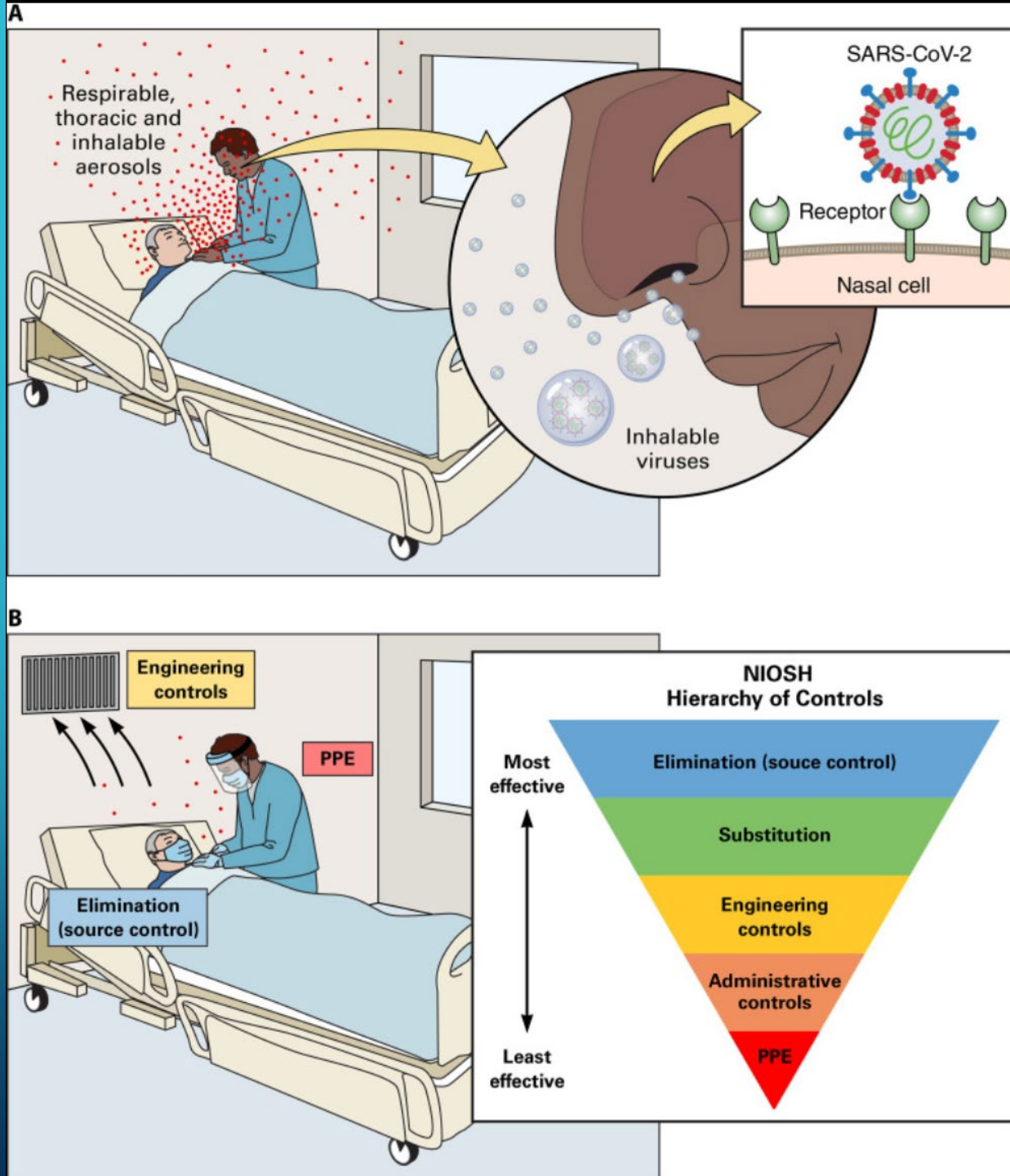
Limites: recherche par PCR, peu de cultures virales et absence de modèle animal

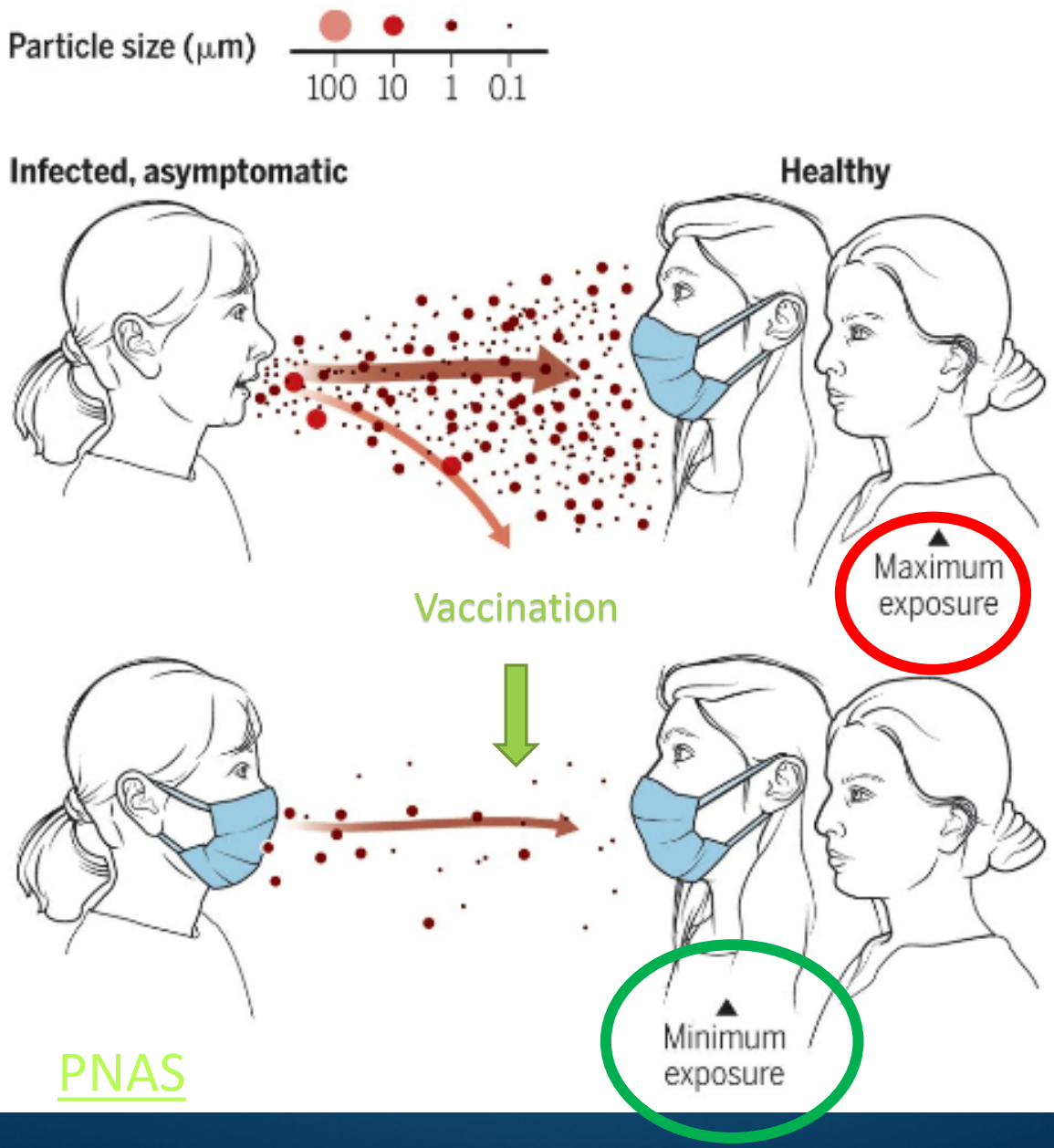
Negative SARS-CoV-2 air sampling studies in health care settingsa.

Study settings	Design	Proportion of positive samples	Strengths (+) and limitations (−)
Cheng et al., 2020 (145) Hong Kong Low- and high-risk (including ICU)	6 pts in AIIR Air sampling: 50 liters/min for 20 min (1,000 liters), 10 cm from pts' chin under an umbrella (air shelter)	Air: 0/6	(+) Increased proportion of exhaled air sampled under the umbrella (+) Sampling with and without mask-wearing (+) Detailed clinical data on pts
Faridi et al., 2020 (200) Iran Mostly high-risk (ICU)	44 hospitalized pts Air sampling: 1.5 liters/min for 1 h (90 liters) in shared pt rooms	Air: 0/10	(+) Detailed information on environment and interventions (−) Lack of clinical data on individual pts (−) Small volume of air sampled
Li et al., 2020 (201) Wuhan, China Low- and high-risk (including ICU)	Designated COVID-19 hospital with 800 severe cases (20 in ICU) Air sampling: 80 liters/min for 30 min (2,400 liters) in 45 areas (low, medium, and high risk)	Air: 0/135	(+) Three replicate samples at each location on separate days (−) 4-time-daily air disinfection (false negative) (−) Qualitative reverse transcriptase PCR
Wu et al., 2020 (147) Wuhan, China Low- and high-risk (including ICU)	Designated COVID-19 hospital Sampling in moderate-risk (buffer room for doffing) and high-risk (pt room) areas	Air: 0/44	(−) No description of pts (−) Unknown air sampling method (−) Open windows and UV light disinfection (potential false negatives)

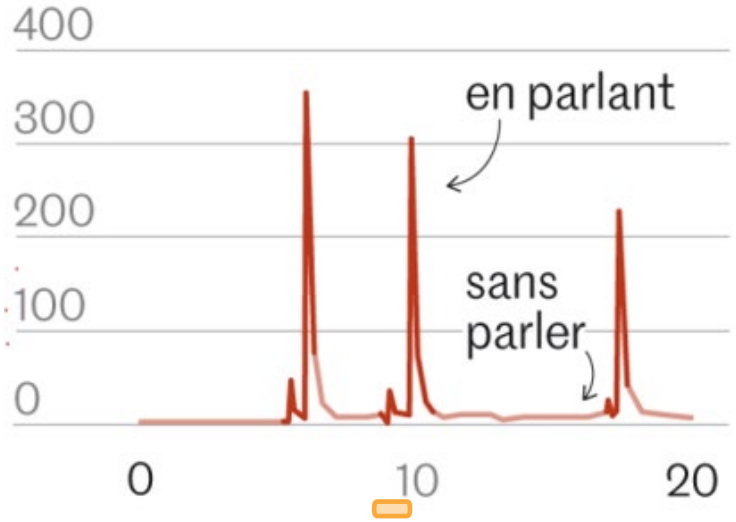
AÉROSOLS INHALABLES VS RESPIRABLES

https://cmr.asm.org/content/34/1/e00184-20.long




Particle size (μm)
100 10 1 0.1
Infected, asymptomatic
Healthy
Maximum exposure
Vaccination
Minimum exposure

PNAS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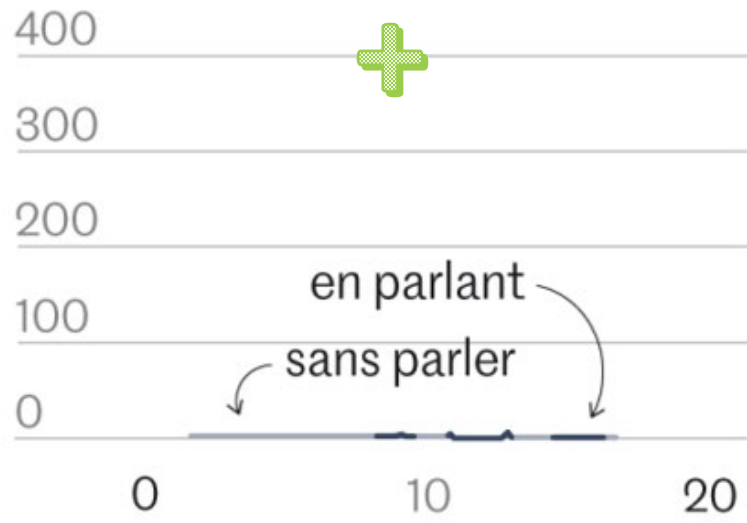
Masque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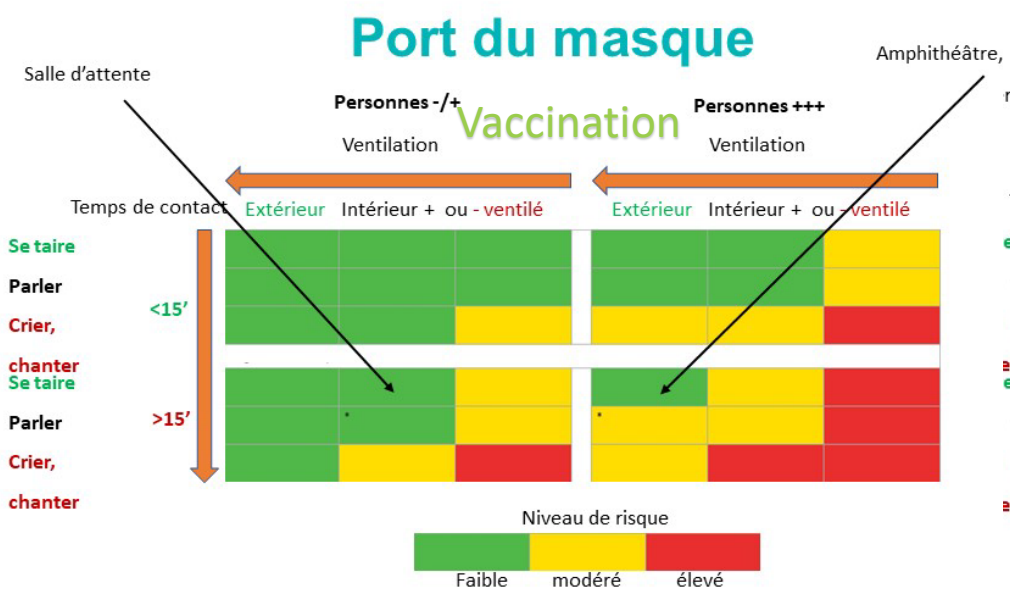
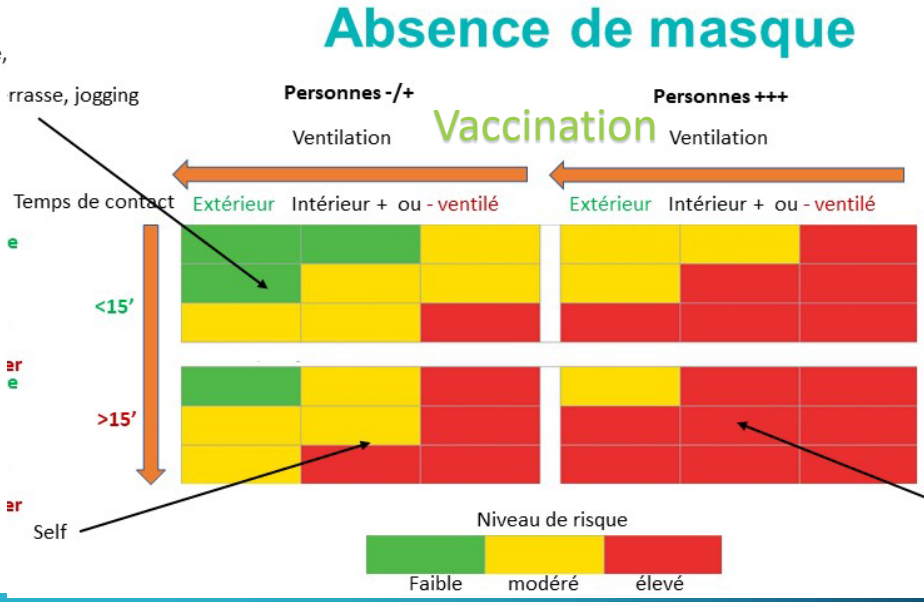




Adapté de https://www.bmj.com/content/370/bmj.m3223

Risk Mode

Si une personne infectée entre...

- Si une personne infectée entre...
- Étant donné le taux d'incidence...
- Pour limiter mon risque personnel...

Espace concerné :

Salle de classe

Comportement des personnes :

Masques, On parle

Seuil de tolérance du risque: 0.10

0.10: Sûr — 1.00: Risqué

Groupe d'âge : 0.68

0.23: Enfants (<15 ans) — 0.68: Adultes (15-64 ans) — 1.00: Personnes âgées (>64 ans)

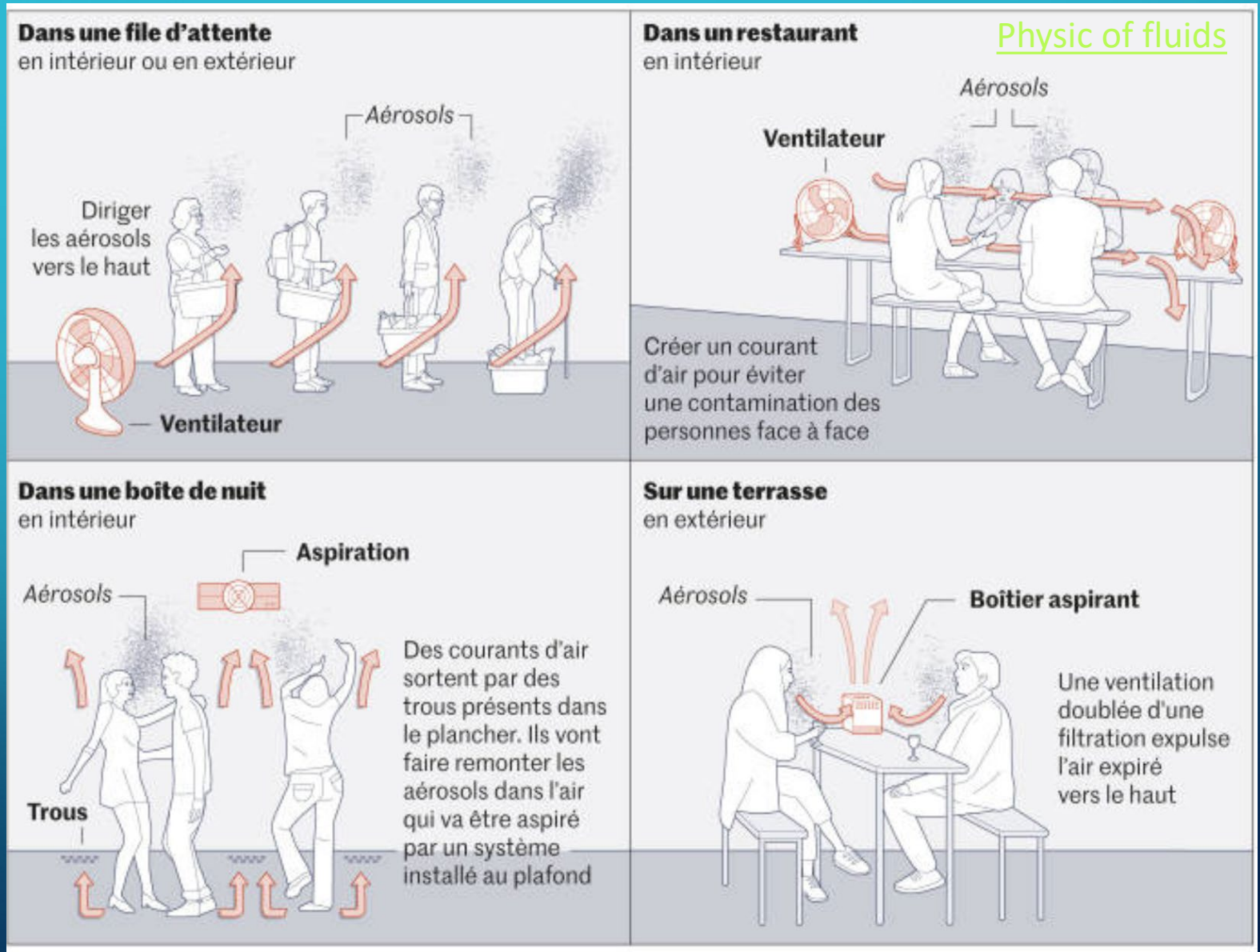
Souche virale : 1.00

1.0: Wuhan — 1.58: B.1.1.7/UK

Proportion de personnes immunisées:0%

https://indoor-covid-safety.herokuapp.com/

MODÈLES DE PRÉVENTION >2M NON FLUX AÉRIENS



Source : F. Poydenot, I. Abdourahamane, E. Caplain, S. Der, J. Haiech, et al., « Risk Assessment for Long and Short Range Airborne Transmission of SARS-CoV-2, Indoors and Outdoors, Using Carbon Dioxide Measurements », 2021, Hal (Archives-ouvertes.fr)

HAP Archives

Infographie : *Le Monde*

Risk Mode

Étant donné le taux d'incidence...

Incidence[1] : 100 pour 100 000

[1]Pour estimer votre taux d'incidence local, voici quelques ressources utiles : en France, covidtracker, CDC COVID-19 Data Tracker, JHU Coronavirus Resource Center, US Immunity Estimates, International Immunity Estimates

72 personnes 4h

36 personnes si tx incidence 400

>111 si 99% immunisés!

Espace concerné :

Restaurant

Comportement des personnes :

Pas de masques, On parle

Seuil de tolérance du risque: 0.10

0.10: Sûr — 1.00: Risqué

Groupe d'âge : 0.68

0.23: Enfants (<15 ans) — 0.68: Adultes (15-64 ans) — 1.00: Personnes âgées (>64 ans)

Souche virale : 2.00

1.0: Wuhan — 1.58: B.1.1.7/UK

Proportion de personnes immunisées:30%

Risk Mode

Étant donné le taux d'incidence...

Incidence[1] : 400 pour 100 000

[1]Pour estimer votre taux d'incidence local, voici quelques ressources utiles : en France, covidtracker, CDC COVID-19 Data Tracker, JHU Coronavirus Resource Center, US Immunity Estimates, International Immunity Estimates

100 personnes 4h

25 personnes 10j

https://indoor-covid-safety.herokuapp.com/

Espace concerné :

Salle de classe

Comportement des personnes :

Masques, On parle

Seuil de tolérance du risque: 0.10

0.10: Sûr — 1.00: Risqué

Groupe d'âge : 0.28

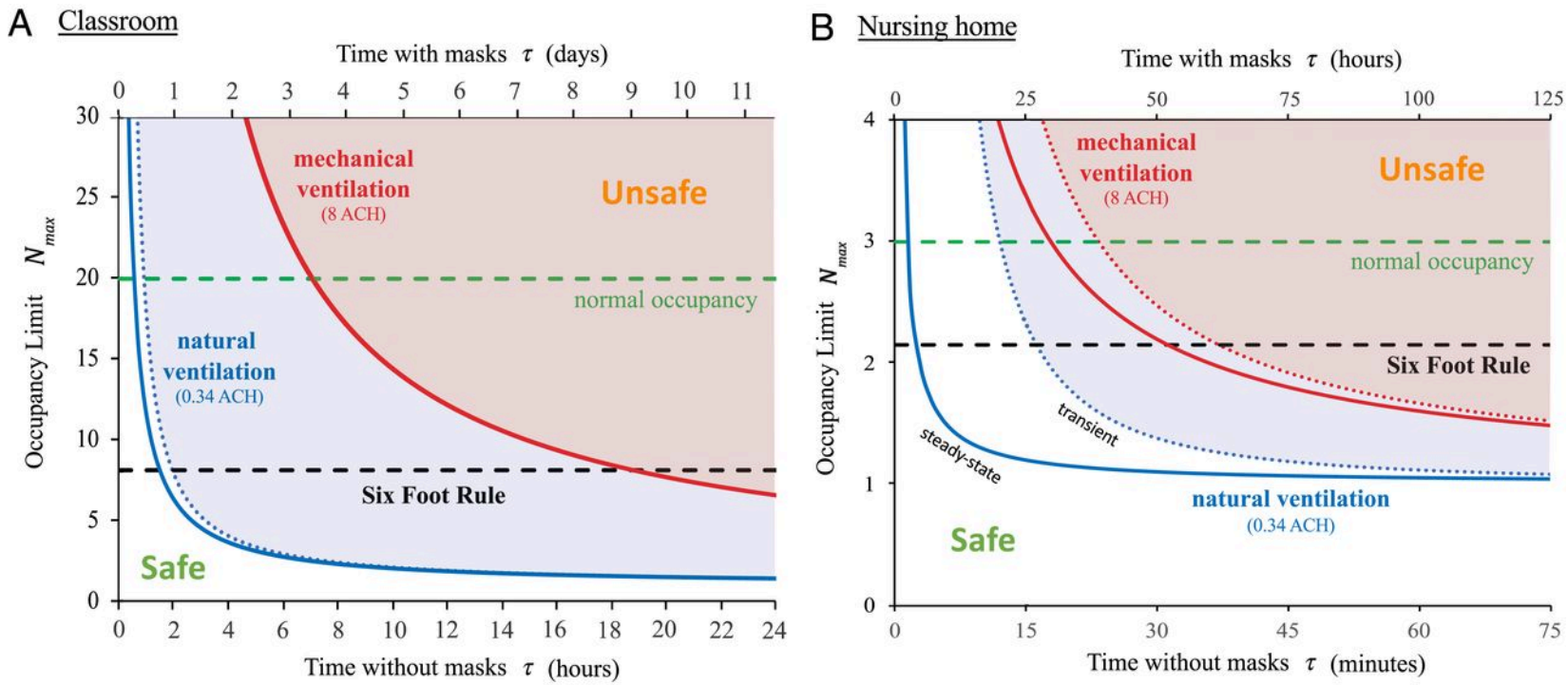
0.23: Enfants (<15 ans) — 0.68: Adultes (15-64 ans) — 1.00: Personne âgées (>64 ans

Souche virale : 2.00

1.0: Wuhan — 1.58: B.1.1.7/UK

Proportion de personnes immunisées:0%

The COVID-19 indoor safety guideline would limit the cumulative exposure time (CET) in a room with an infected individual to lie beneath the curves shown.



1 Vaccination → zone « safe » si > 90% taux vaccinés adultes. Enfants?

2 Aération des locaux et détecteurs CO2

3 Mesures adaptées selon évaluation du risque

Martin Z. Bazant, and John W. M. Bush PNAS 2021;118:17:e2018995118