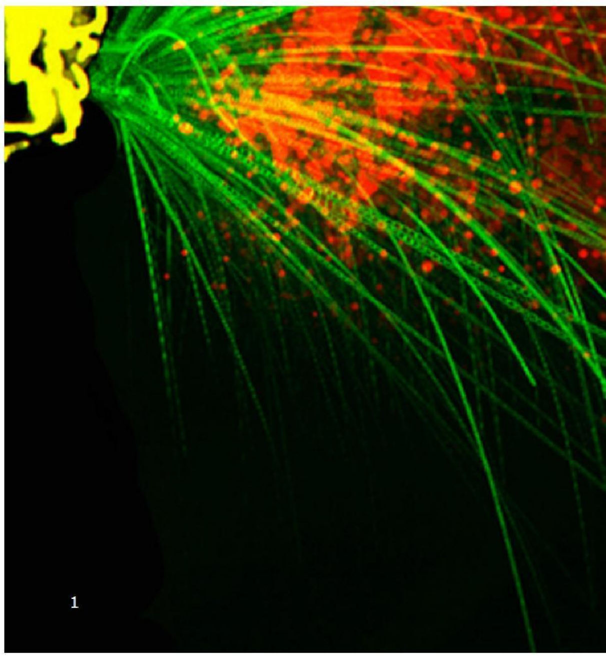
1046762



Wells-Riley / Schijven et al.

Discussie over aerogene trans

5.1.2e

Aerogene transmissie werkgroep

Vergelijking Wells-Riley en Schijven et al.

- overeenkomsten en verschillen
- strength and limitations
- aannames
- vertalingen naar beleid

Wells- Riley Tool & Schijven et al. Tool beiden:

- Doen een aanname over uitscheidingshoeveelheid virus (verschilt)
- Afmetingen en ventilatie in een bepaalde ruimte
- Aantal bevattelijke personen in die ruimte
- Ademhalingsvolume van bevattelijke personen
- Berekening concentratie over tijdsverloop in ruimte

Wells- Riley

- Meestal fit op uitbraak data
- Sterk bepaald door gekozen uitbraak (the quanta generation rate of tuberculosis calculated from different outbreaks ranged from 1.25 to 30,840 quanta/h (Beggs et al., 2003).)
- Emissie-quanta
- Alle geobserveerde gevallen in de dataset via de airborne route geïnfecteerd
- Nuttige modellen wanneer alleen uitbraakdata beschikbaar zijn, maar weinig bekend is over de virusuitscheiding en dosis-respons.

Schijven et al.

- Gebaseerd op virale concentraties in neus / keel
- Veel variatie (10^{2}-10^{11} RNA/mL)

- Concentraties en dosis-respons
- Alleen berekeningen voor airborne route

Wells- Riley

- Geen helder conceptueel onderscheid tussen blootstelling en effect
- Beide worden een beetje in 1 entiteit weggemoffeld: het zg quantum, dat deels de hoeveelheid ge-emitteerde virusdeeltjes representeert, maar deels ook het risico op infectie bij inademing van een (of meer?) deeltjes

Schijven et al.

- Een dosis-respons model maakt helderder onderscheid tussen de twee, waarbij effect en dosis apart bepaald worden en pas in een risico bepaling samengebracht.

1046762

Hier volgen een aantal slides doorgestuurd door Marcel Loomans van TuE

TU/e

Rekenen aan een besmettingskans

Wells-Riley…

$$N_C = S\left(1 - e^{-Iqpt/Q}\right)$$

Aantal geïnhaleerde quanta

N_c [-] Aantal nieuw geïnfecteerde cases
S [-] Aantal mensen dat mogelijk geïnfecteerd kan worden in de te onderzoeken ruimte
I [-] Aantal geïnfecteerde personen in de ruimte
q [quanta/h] Aantal zogenaamde 'quanta' dat in de ruimte wordt geproduceerd door een geïnfecteerd persoon
p [m^3/h] Ademhalingsvolume van een persoon die mogelijk geïnfecteerd kan worden
t [h] Blootstellingstijd
Q [m^3/h] Ventilatie in de ruimte die wordt onderzocht

1 quantum ?

besmettingskans = $1-e^{-1}$ = 63%

1 quantum niet (per se) 1 druppeltje/aerosol/virusdeeltje

'Bron'
'Sink'

Binnenklimaat Nederland · VCCN · ISSO · TVVL · Masterplan Ventilatie

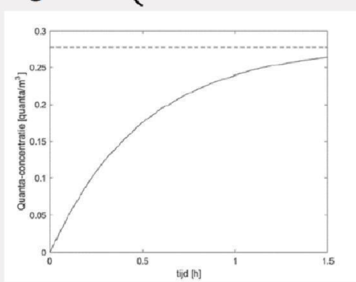
1046762

TU/e

Rekenen aan een besmettingskans

Wells-Riley…

$$N_C = S\left(1 - e^{-Iqpt/Q}\right)$$



Belangrijke uitgangspunten, o.a.

- Incubatietijd > tijdsduur onderzochte situatie
- Perfect gemengde situatie (kleine/grote ruimtes)
- Gemiddelde concentratie over tijdsduur
- Uniform verloop besmetting
- Enkel ventilatie; maar bijv. filtratie of depositie, laten zich als verliesterm ('sink') meenemen

  $Q = \lambda_v \cdot V$; λ_v [h^{-1}] ventilatievoud, V [m^3] volume.

  λ_{dep} [h^{-1}] depositie

  λ_{fil} [h^{-1}] filtratie

- Masker, effect op productie en/of ingeademde hoeveelheid

Binnenklimaat NEDERLAND   vccn   ISSO   TVVL   MASTER VENTIL

TU/e

Rekenen aan een besmettingskans

Wells-Riley…

$$N_C = S\left(1 - e^{-Iqpt/Q}\right)$$

Belangrijke uitgangspunten

- Bepaling quanta
- Retrospectief: Op basis van cases (niet alle routes afzonderlijk)
- Prospectief: hoeveelheid virus in speeksel, conversie factor (quanta per RNA copies), ademhalingsvolume, concentration druppeltjes volume.

Retrospectief…

Skagit Valley koor repetitie [7]

How a superspreader at choir practice sickened 52 people with COVID-19

By Laura Geggel - Associate Editor May 14, 2020

Prospectief…

		Resting, oral breathing	Heavy activity, oral breathing	Light activity, speaking	Light activity, singing (or speaking loudly)
ER_q	5th percentile	2.4×10^{-2}	1.6×10^{-1}	3.2×10^{-1}	2.1×10^{0}
	25th percentile	1.2×10^{-1}	8.2×10^{-1}	1.6×10^{0}	1.0×10^{1}
	50th percentile	3.7×10^{-1}	2.5×10^{0}	5.0×10^{0}	3.2×10^{1}
	75th percentile	1.1×10^{0}	7.7×10^{0}	1.5×10^{1}	9.8×10^{1}
	90th percentile	3.1×10^{0}	2.1×10^{1}	4.2×10^{1}	2.7×10^{2}
	95th percentile	5.7×10^{0}	3.8×10^{1}	7.6×10^{1}	4.9×10^{2}
	99th percentile	1.7×10^{1}	1.2×10^{2}	2.4×10^{2}	1.5×10^{3}
$\log_{10}(ER_q)$	Average	-4.29×10^{-1}	3.99×10^{-1}	6.98×10^{-1}	1.50×10^{0}
	Stand. dev	7.20×10^{-1}	7.20×10^{-1}	7.20×10^{-1}	7.20×10^{-1}

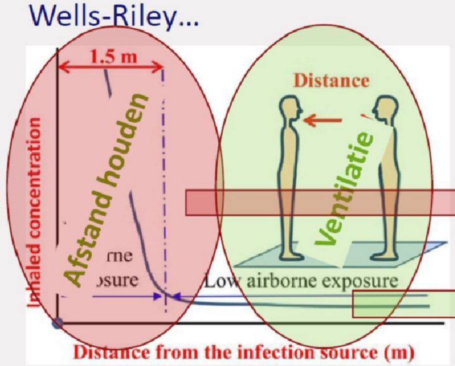
[8]

Binnenklimaat Nederland · vccn · ISSO · TVVL · MASTERPLAN VENTILATIE

1046762

Rekenen aan een besmettingskans

Wells-Riley…



[3]

Alleen luchttransmissieroute!

- **Afstand houden!** = directe route
(bijdrage aerosolen)

- Wells-Riley geeft indruk van kans
- Absolute waarde voorzichtig mee om gaan
- Vergelijk tussen situaties/oplossingen (relatief)

Collega [redacted] 5.1.2e:

- Wells-Riley tool wordt geimplementeerd in een zg 'Quickscan COVID 19'.
- Op dit moment kijkt (blijkbaar) deze tool alleen naar de ventilatiekwaliteit en beoordeelt of deze goed is of beter moet, uiteindelijk willen de makers van de tool naar een soort infectie-risico schatting ('rekentool besmettingskansen') door inbouwen van Wells-Riley.
- Om dit te kunnen doen moet je dat zg 'quantum' uit het Wells-Riley model quantificeren. Dit gebeurt op dit moment op basis van een COVID-case studie van (G. Buonanno, L. L. Stabilea en L. Morawska, „Estimation of airborne viral emission: Quanta emission rate of SARS-CoV-2 for infection risk assessment," Environment International, nr. 141, 2020.), maar deze beschouwen ze als erg onzeker en er wordt gewerkt aan een andere methode.
- Dit heeft tot gevolg dat de auteurs van de tool adviseren de uitkomsten van de berekeningen niet als een absolute kans op infectie te beschouwen, maar alleen als een relatieve kans (vgl met een ander scenario dus).
- Volgens mij is het uiteindelijk dus geen risicobeoordelingsinstrument, maar meer een soort van prioriteringstool voor verschillende ruimtes/scenario's.

Discussie over definities en argumentatie rond aerogene transmissie

Problem – RIVM and other institutes maintain that droplet transmission is predominant route without solid evidence

1. Definition problem
2. Faulty argumentation
3. Burden of proof
4. Measures

Definition problem

- CDC (5 Oct. 2020 https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html): "Droplet transmission consists of exposure to larger droplets, smaller droplets, and particles when a person is close to an infected person. Airborne transmission consists of exposure to smaller droplets and particles at greater distances or over longer times. [...]The epidemiology of SARS-CoV-2 indicates that most infections are spread through close contact, not airborne transmission "

- WHO (current online version, dated 9 July https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions): "Respiratory droplets are >5-10 μm in diameter whereas droplets <5μm in diameter are referred to as droplet nuclei or aerosols.(11) Respiratory droplet transmission can occur when a person is in close contact (within 1 metre) with an infected person [...] Airborne transmission is defined as the spread of an infectious agent caused by the dissemination of droplet nuclei (aerosols) that remain infectious when suspended in air over long distances and time."

- RIVM (current online version, dated 28 July): "De huidige richtlijnen voor preventie van SARS-CoV-2 verspreiding zijn gebaseerd op de aanname dat mens-op-menstransmissie van SARS-CoV-2 voornamelijk direct plaatsvindt binnen een afstand van 1,5 m via druppelinfectie (via druppels met een diameter > 5-10 μm) die vrijkomen bij hoesten en niezen, of indirect via contact met besmette voorwerpen of oppervlakken (WHO, CDC)."

Definition problem

The definition is medical, epidemiological:

- Droplet transmission is transmission observed within 1.5 meter
- Airborne transmission is transmission observed over larger distances than 1.5 meter

≠

This is **not equal** to stating:

- Droplet transmission is transmission through droplets that fall on the ground within 1.5 meter
- Airborne transmission is transmission through smaller droplets and droplet nuclei that can stay airborne over longer distances

≠

This is **also not equal** to stating:

- Droplet transmission is transmission through droplets > 5-10 micrometer
- Airborne transmission is transmission through droplets <5 micrometer

First problem: **mixing up these definitions**

Faulty argumentation 1

- Transmission within a distance of 1.5 m is caused by droplets >5-10 micrometer that fall to the ground quickly. The fact that the 1.5 m distance rule works is proof for droplet transmission as main route.

Counter

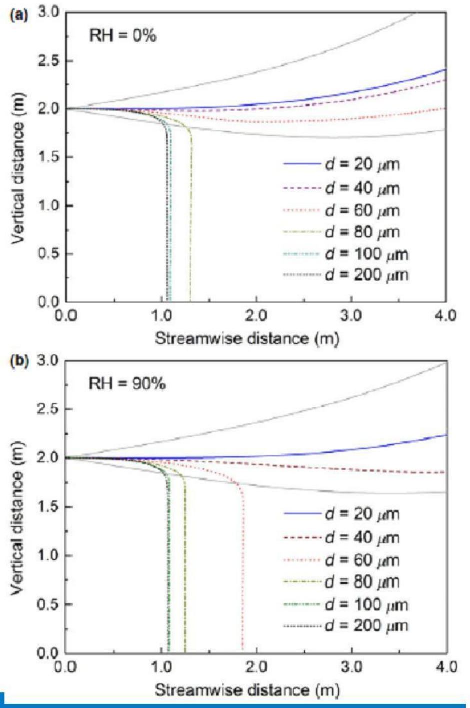
- Definitions are mixed up
- There is no proof that transmission within 1.5 m is actually caused by large droplets. Nor is there a plausible reason that transmission within 1.5 m distance cannot be caused by aerosols.
- In fact, dilution of aerosols around the source makes transmission close by more likely than further away
- Keeping 1.5 m distance and consequently having less people together in a space therefore make airborne transmission also less likely to occur
- Droplets up to at least 60 micrometer can stay airborne

1046762

Incorrect aerosol size description

Fact: Droplets up to **at least 60 micrometer** can stay airborne.

See for example Liu et al. 2017.



Faulty argumentation 2

- Measles is a classical example of an airborne disease. It has an R0 of around 11, whole waiting rooms at the doctor's office get infected when a patient has been there. We do not see such numbers for COVID-19. This is proof that aerosols are not the predominant route for COVID-19.

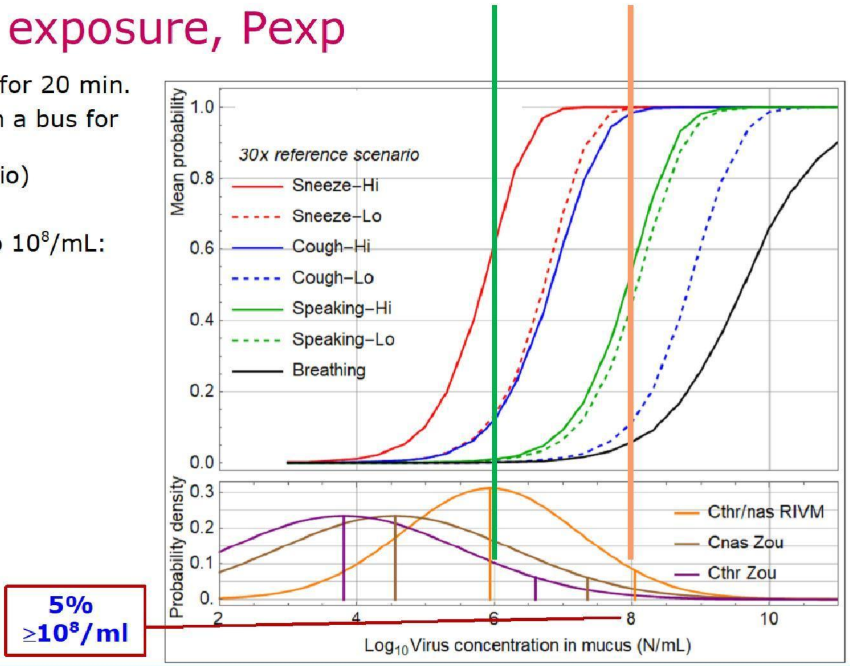
Counter

- This is confusing an artifact of history with a law of nature. There is no reason that nature can only produce highly transmissible aerosol-transmitted diseases.
- The R0 is an average, and overdispersion is seen (value k). I.e. for COVID-19, it is thought that ~10% of infected individuals cause ~80% of transmission. See for example Endo et al. https://wellcomeopenresearch.org/articles/5-67/v3
- Viral loads varying over 10^{2}-10^{11} RNA copies / mL mucus (RIVM data) also suggest strongly that not all individuals contribute equally to transmission.
- Our exposure assessment suggested that only the ~5% of individuals with the highest viral loads would cause significant exposure via aerosols

Probability of exposure, Pexp

- 1 person expels virus for 20 min.
- 30 persons exposed in a bus for 20 min. (30x reference scenario)

- Mean Pexp in scenario 10^8/mL:
  Sneeze-Hi 100%
  Sneeze-Lo 100%
  Cough-Hi 98%
  Speaking-Hi 55%
  Speaking-Lo 46%
  Cough-Lo 11%
  Breathing 6%



Faulty argumentation 3

- In the majority of situations where an infected individual was present in a group where hygiene and distancing was observed, this did not cause a mass outbreak. This is proof that droplet transmission is the main route, and airborne transmission plays little role.

Counter

- Overdispersion, for COVID-19, it is thought that ~10% of infected individuals cause ~80% of transmission.
- This means that 90% of the infected individuals present in any group will not be causing a mass outbreak. The fact that this is observed is not proof for droplet transmission as main route.

Arguments specifically pointing to transmission via aerosols as important route for COVID-19

- More transmission is observed indoors than outdoors (odds 18.7 to 1, Nishiura, 2020)
- The occurrence of superspreading events with high R0 (~20)
- Demonstrated to occur with ferrets (Kutter, 2020) and hamsters (Sia, 2020)
- Infectious virus has been detected in air 2-5 meter away from patients (6 to 74 TCID50 units/L of air) (Lednicky, 2020)
- Lab experiments show that virus can stay infective in aerosols for hours (~1 log reduction infectious titer in 3 hours) (Van Doremalen, 2020)
- Models indicate that the short-range airborne route dominates exposure of respiratory infection during close contact. The large droplet route only dominates when the subjects are within 0.2 m while talking or 0.5 m while coughing. (Chen, 2020)
- Similarly, for influenza A RIVM work indicates that droplet and aerosols contribute approximately equally to transmission (Teunis, 2010)
- Perhaps the fact that non-medical masks are only moderately protective and well-fitted FFP2 masks are protective? Both capture larger droplets, but aerosols can move with the air flow around the edges of a non-fitted mask.

More evidence for transmission via different routes

	Droplets	Fomites	Aerosols
Outdoors << Indoors	X	✓	✓✓
Similar viruses demonstrated	X	✓	✓
Animal models	?	✓	✓
Superspreading events	X	X	✓✓
Supersp. Patterns similar to known aerosol diseases	n/a	n/a	✓
Importance of close proximity	✓	X	✓✓
Consistency of close prox. & room-level	X	X	✓
Physical plausibility (talking)	X	✓	✓
Physical plausibility (cough, sneeze)	✓	✓	✓
Impact of reduced ventilation	X	X	✓
SARS-CoV-2 infectivity demonstrated in real world	X	X	✓
SARS-CoV-2 infectivity demonstrated in lab	X	✓	✓
"Droplet" PPE works reasonably well	✓	✓	✓
Transmission by a/pre-symptomatics (no cough)	X	✓	✓
Infection through eyes	✓	✓	✓
Transmission risk models	✓	✓	✓

Key:
✓: evidence
✓✓: very strong ev.
X: no evidence
X: evidence against
n/a: not applicable
(v1.45, 13-Sep-2020)

Only including the items that could bear on multiple pathways. See other slides for details and references

Table: preliminary summary of the evidence supporting each of the three routes of transmission. Aerosols has the most supporting evidence. Fomites has significant supporting evidence. Ballistic droplets have very little supporting evidence.

22 FAQs on Protecting Yourself from COVID-19 Aerosol Transmission. https://tinyurl.com/FAQ-aerosols. Version: 1.78, 1-Oct-2020

Valid arguments specifically against transmission via aerosols

- None...?

Burden of proof

- There is no direct proof that transmission within 1.5 m occurs through large droplets and not aerosols
- There is abundant evidence pointing in the direction of transmission via aerosols

- Sticking with the medical definition that 'we call transmission within 1.5 m droplet transmission and transmission further away airborne transmission' does not really make sense, and is in fact misleading

1046762

Measures

For a large part consistent!

- 1.5 meter rule still important
- Preventing gatherings of large groups, especially indoors, still important
- Staying at home when symptomatic still important

...just not for the reasons often stated!

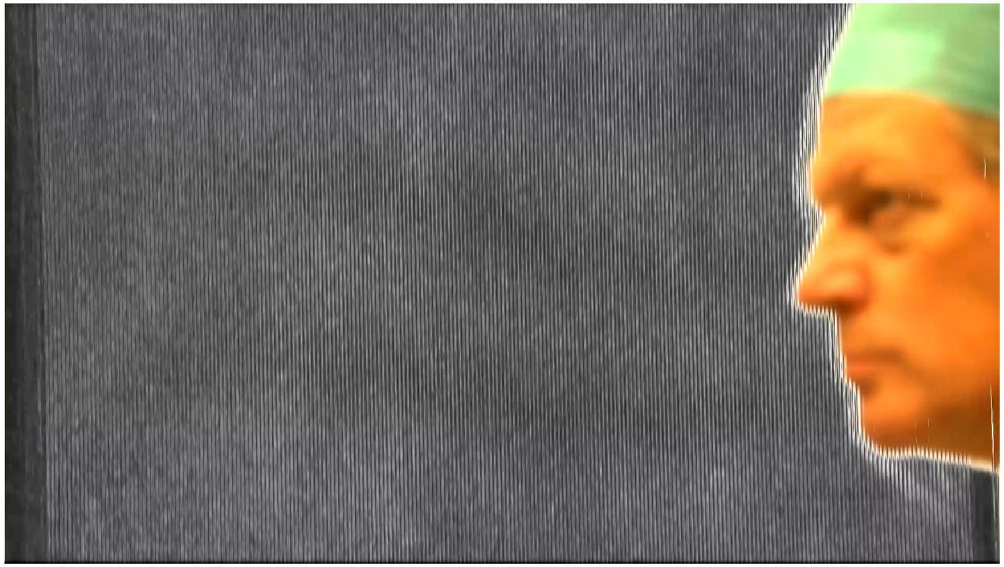
But maybe not enough attention is given to:

- The behavior of asymptomatics
- Time spent in the same room (indoors)
- (Indoor) activities with elevated aerosol production, such as choir rehearsals, indoor group sports lessons, ...
- Ventilation → is het Bouwbesluit sufficient?
- Air purification?
- ... others?

Some nice imaging on droplets and air flow with and without masks

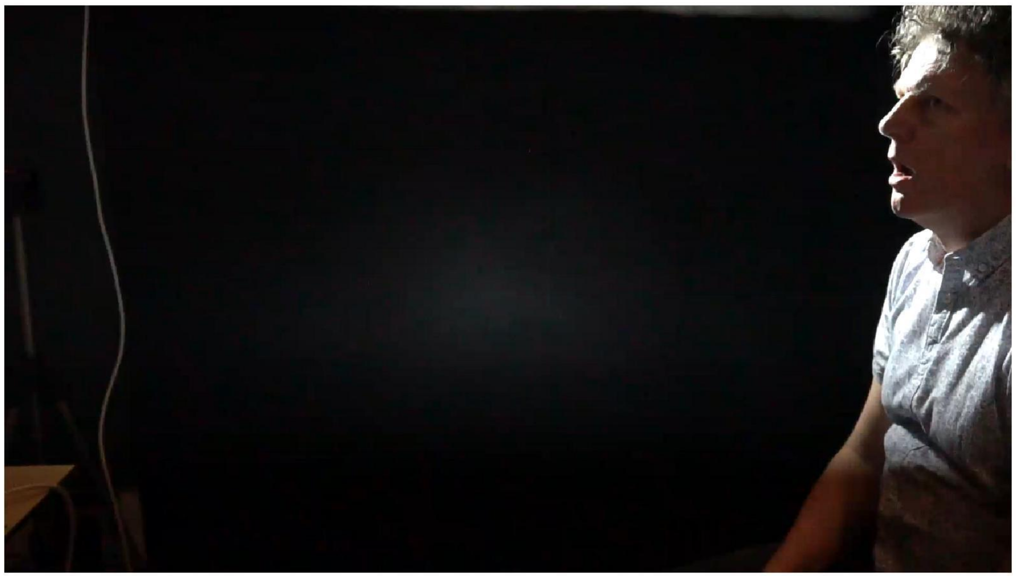
Imaging courtesy of Rudolf Verdaasdonk, Chair of Health Technology Implementation, TechMed Center, University of Twente

Breathing air flow



normal speed and 4x slow motion

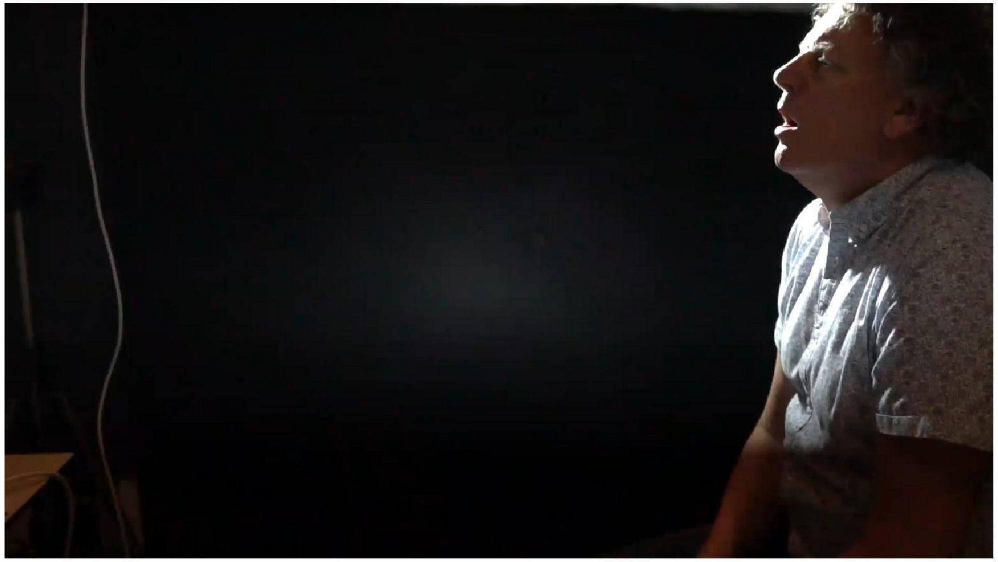
water fume and droplets (exaggerated)



normal speed and 16x slow motion

ezi

Water fume and droplets (exaggerated)



ng
air flow

normal speed and 4x slow motion

coughing in surgical mask for prevention of

normal speed and 16x slow motion