Routes of Transmission and principles of transmission interruption

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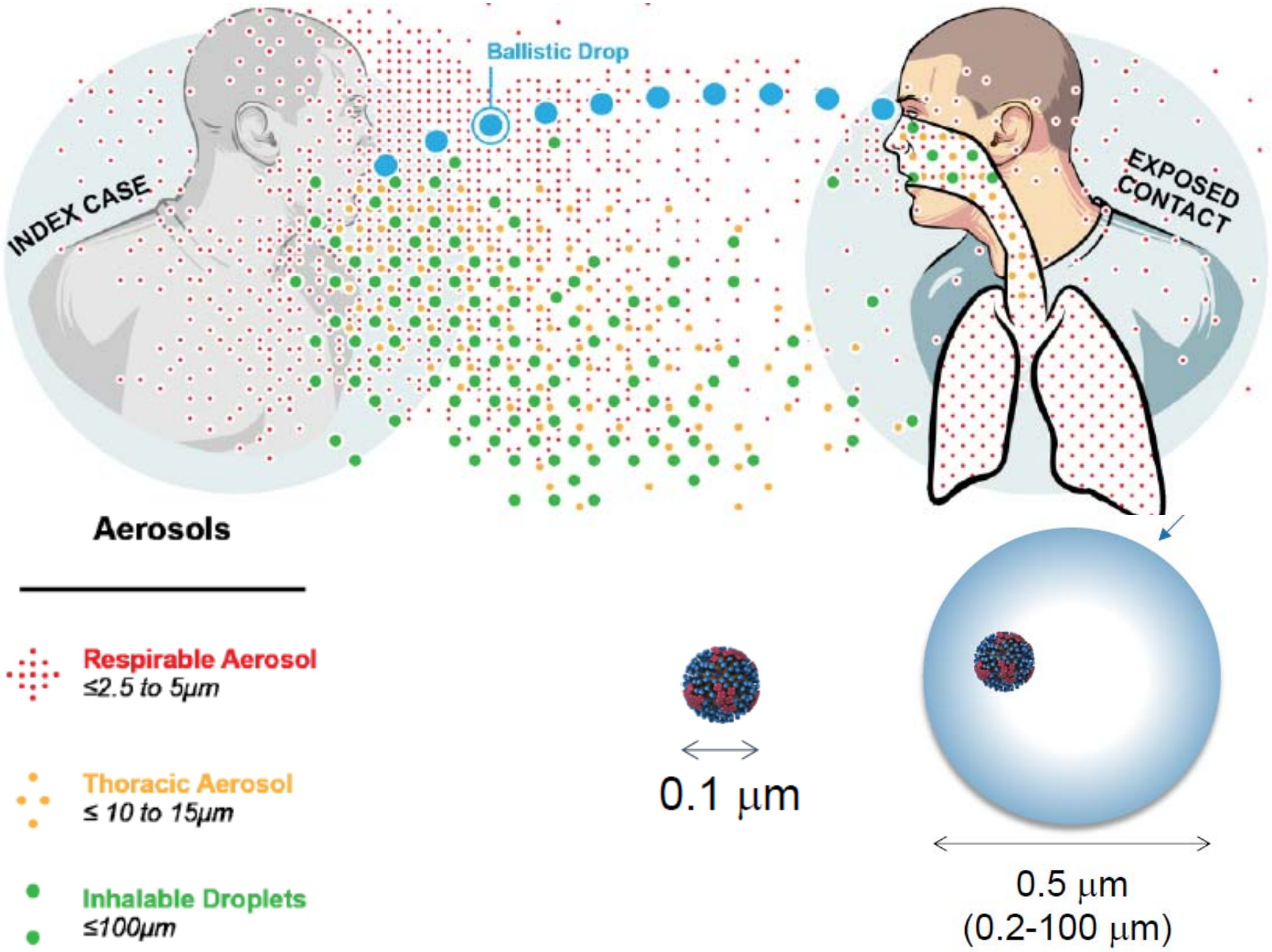
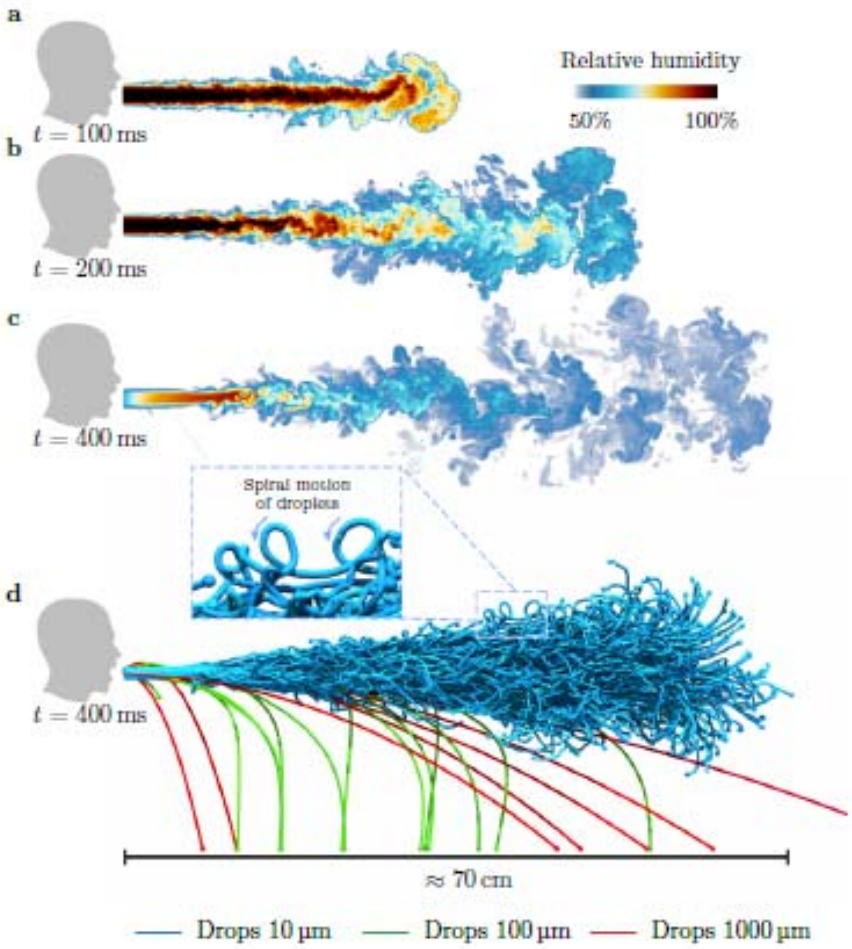
Transmission of respiratory viruses: 3 routes of transmission

- Contact with secretions loaded with viruses (direct or indirect: fomites), followed by self inoculation
- Large droplets that fall quickly on the ground
- Aerosol sized- droplets that linger in the air and can follow air flow



Milton DK J Ped Infect Dis Soc 8:4 2020; and courtesy of Dr L. Marr

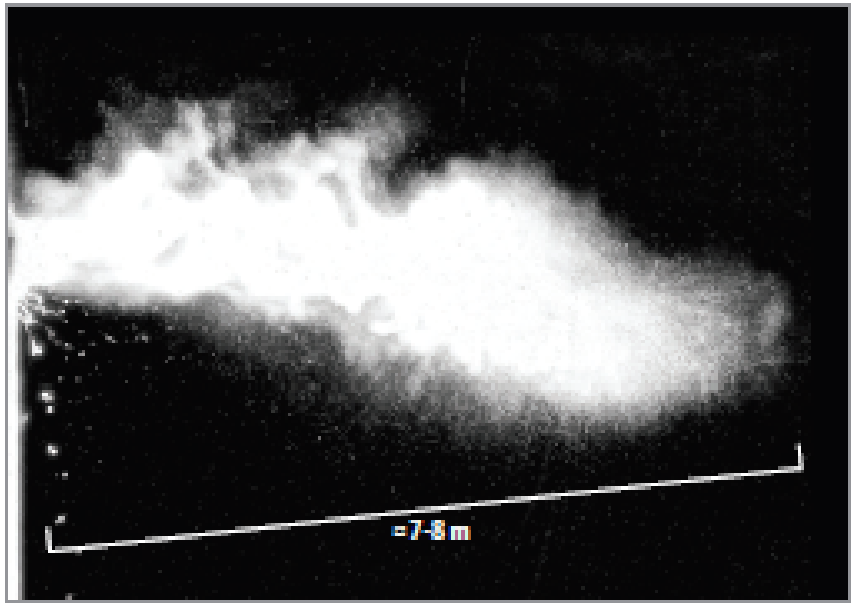
Aerodynamic diameter of particle	Settling time in still air (3 m fall)
100 μm	10 sec
40 μm	1 min
20 μm	4 min
10 μm	17 min
5 μm	67 min
3 μm	3.1 hours
1 μm	27.8 hours



Cheong KL et al Extended lifetime of respiratory droplets in a turbulent vapour puff and its implication on airborne disease transmission Preprint August 2020

Horizontal distance traveled on an horizontal jet emitted at height of 2m; RH 50% (NaCl 0.9%)
Xie et al Indoor Air 2007; 17: 211-225

Figure. Multiphase Turbulent Gas Cloud From a Human Sneeze



JAMA Insights

Turbulent Gas Clouds and Respiratory Pathogen Emissions
Potential Implications for Reducing Transmission of COVID-19

Lydia Bourouiba, PhD

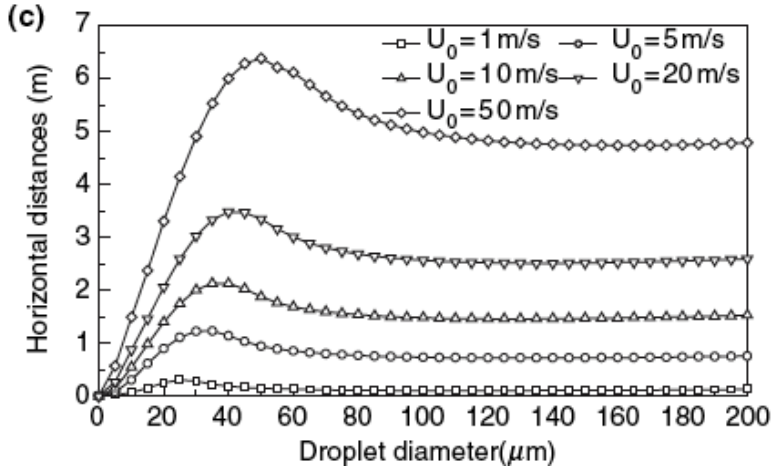


TABLE I. Aerosol Administration of Influenza A2/Bethesda/10/63 to Volunteers.

Inhaled virus ($TCID_{50}$)	Vol #	Illness	Virus recovery (days after inoc)	Neutralization antibody: Before inoculation	Neutralization antibody: 28 days after
126	1	*	*	1280	2560
	2			2560	2560
	3			640	1280
78	4			160	160
	5			320	320
	6			320	320
59	7			40	1280
	8			80	80
	9			80	80
1	10	+	3–7	<5	80
2	11			<5	<5
	12			<5	<5
	13			<5	<5
	14		4–7	<5	320
5	15			40	40
	16			80	80
	17			40	40
	18	+	4, 7	10	1280
	19			20	1280
	20	+	2–6	5	5120
	21			<5	<5
	22	+	2–6	<5	640
	23			<5	<5

* Blank spaces indicate no response.

Alford RH et al Proc Soc Exp Biol Med 1966; 122: 800-804

1 to 3 µm

Comparison of human infectious dose of influenza virus by aerosol or intranasal route

- Aerosol:
  HID_{50} = 0.6 to 3 $TCID_{50}$

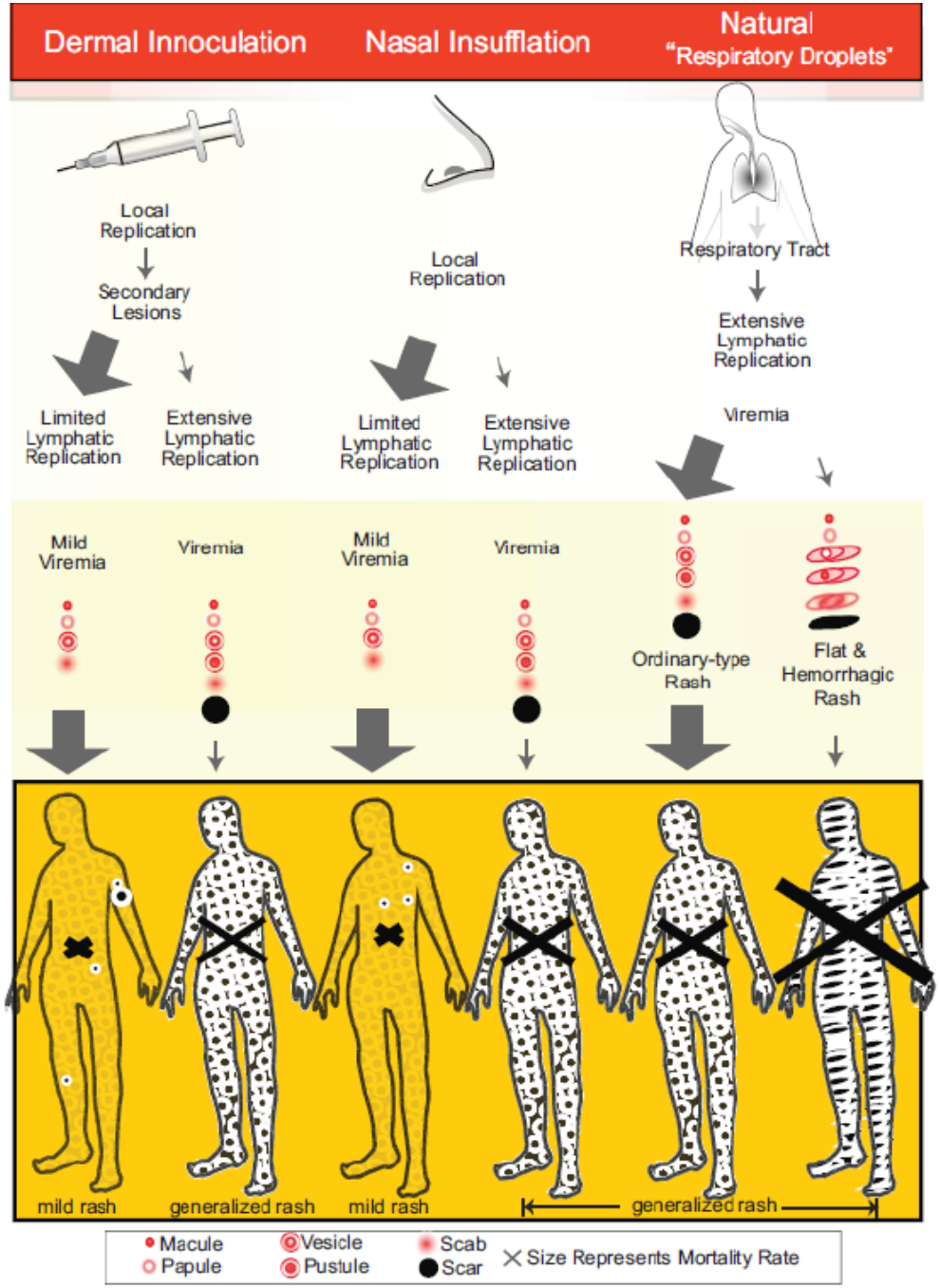
- Intranasal (large droplet)
  HID_{50} = 127 to 320 $TCID_{50}$

(Douglas R.G. Influenza in Man. Pp 375-447 in
The Influenza Viruses and Influenza, Kilbourne E.D. ed,
Academic Press, New York 1975.)

Diseases caused by experimental influenza infections in humans

- by the aerosol route: disease is very similar to that seen in natural infections.
- by intranasal drops (large droplets): disease is milder, with a longer incubation period and usually no involvement of the lower respiratory tract.

1) Douglas R.G. Influenza in Man. Pp 375-447 in The Influenza Viruses and Influenza, Kilbourne E.D. ed, Academic Press, New York 1975
2) Little J.W. et al J Med Virol 3: 177-188, 1979.
3) Knight V.pp. 175-182 in: Hers JF, Winkles KC, eds. Airborne Transmission and Airborne Infections VIth International Symposium on Aerobiology. New York: Wiley; 1973



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The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Evidence of Airborne Transmission of the Severe Acute Respiratory Syndrome Virus

Ignatius T.S. Yu, M.B., B.S., M.P.H., Yuguo Li, Ph.D., Tze Wai Wong, M.B., B.S., Wilson Tam, M.Phil., Andy T. Chan, Ph.D., Joseph H.W. Lee, Ph.D., Dennis Y.C. Leung, Ph.D., and Tommy Ho, B.Sc.

N Engl J Med 2004;350:1731-9.

Clin Infect Dis. 2016 Aug 1; 63(3): 363–369.
Published online 2016 Apr 18. doi: 10.1093/cid/ciw239: 10.1093/cid/ciw239

PMCID: PMC7108054
PMID: 27090992

Extensive Viable Middle East Respiratory Syndrome (MERS) Coronavirus Contamination in Air and Surrounding Environment in MERS Isolation Wards

Sung-Han Kim,✉ So Young Chang, Minki Sung, Ji Hoon Park, Hong Bin Kim, Heeyoung Lee, Jae-Phil Choi, Won Suk Choi, and Ji-Young Min

OPEN

Aerosol and surface contamination of SARS-CoV-2 observed in quarantine and isolation care

Joshua L. Santarpia[1,2], Danielle N. Rivera[2], Vicki L. Herrera[1], M. Jane Morwitzer[1], Hannah M. Creager[1], George W. Santarpia[1], Kevin K. Crown[2], David M. Brett-Major[1], Elizabeth R. Schnaubelt[1,3], M. Jana Broadhurst[1], James V. Lawler[1,2], St. Patrick Reid[1] &

ARTICLE

https://doi.org/10.1038/s41467-020-16670-2 OPEN

Check for updates

Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients

Po Ying Chia[1,2,3,11], Kristen Kelli Coleman[4,11], Yian Kim Tan[5,11], Sean Wei Xiang Ong[1,2,11], Marcus Gum[5], Sok Kiang Lau[5], Xiao Fang Lim[5], Ai Sim Lim[5], Stephanie Sutjipto[1,2], Pei Hua Lee[1,2], Than The Son[4], Barnaby Edward Young[1,2,3], Donald K. Milton[6], Gregory C. Gray[4,7,8], Stephan Schuster[9], Timothy Barkham[2,10], Partha Pratim De[2,3], Shawn Vasoo[1,2,3], Monica Chan[1,2], Brenda Sze Peng Ang[1,2,3,10], Boon Huan Tan[5], Yee-Sin Leo[1,2,3,10], Oon-Tek Ng[1,2,3,12], Michelle Su Yen Wong[5,12], Kalisvar Marimuthu[1,2,10,12] & for the Singapore 2019 Novel Coronavirus Outbreak Research Team*

nature

https://doi.org/10.1038/s41586-020-2271-3

Accelerated Article Preview

Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals

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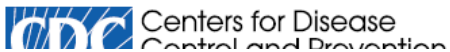
Yuan Liu, Zhi Ning, Yu Chen, Ming Guo, Yingle Liu, Nirmal Kumar Gali, Li Sun, Yusen Duan, Jing Cai, Dane Westerdahl, Xinjin Liu, Ke Xu, Kin-fai Ho, Haidong Kan, Qingyan Fu & Ke Lan



Volume 26, Number 7—July 2020

Dispatch

Aerosol and Surface Distribution of Severe Acute Respiratory Syndrome Coronavirus 2 in Hospital Wards, Wuhan, China, 2020

Zhen-Dong Guo[1], Zhong-Yi Wang[1], Shou-Feng Zhang[1], Xiao Li, Lin Li, Chao Li, Yan Cui, Rui-Bin Fu, Yun-Zhu Dong, Xiang-Yang Chi, Meng-Yao Zhang, Kun Liu, Cheng Cao, Bin Liu, Ke Zhang, Yu-Wei Gao✉, Bing Lu✉, and Wei Chen✉

Journal Pre-proof

Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patients

John A. Lednicky, Michael Lauzardo, Z. Hugh Fan, Antarpreet Jutla, Trevor B. Tilly, Mayank Gangwar, Moiz Usmani, Sripriya Nannu Shankar, Karim Mohamed, Arantza Eiguren-Fernandez, Caroline J. Stephenson, Md. Mahbubul Alam, Maha A. Elbadry, Julia C. Loeb, Kuttinchantran Subramaniam, Thomas B. Waltzek, Kartikeya Cherabuddi, J. Glenn Morris Jr., Chang-Yu Wu

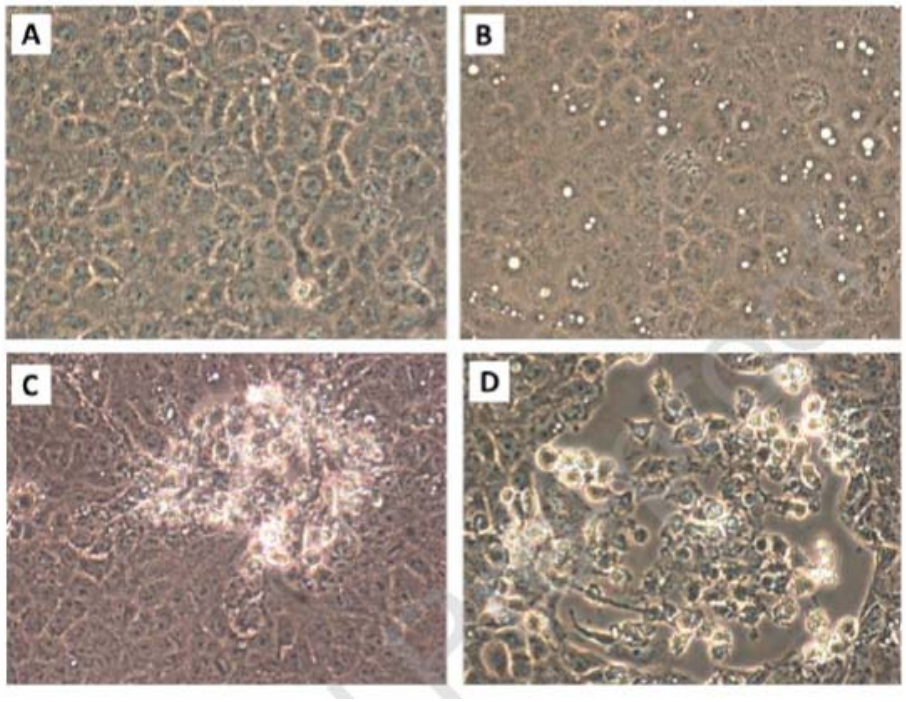
PII: S1201-9712(20)30739-6

DOI: https://doi.org/10.1016/j.ijid.2020.09.025

The Infectious Nature of Patient-Generated SARS-CoV-2 Aerosol

Joshua L. Santarpia[1,2*+], Vicki L. Herrera[1], Danielle N. Rivera[2], Shanna Ratnesar-Shumate[1], St. Patrick Reid[1*], Paul W. Denton[3], Jacob W.S. Martens[3], Ying Fang[4], Nicholas Conoan[1], Michael V. Callahan[5], James V. Lawler[1], David M. Brett-Major[1] and John J. Lowe[1*]

1. University of Nebraska Medical Center



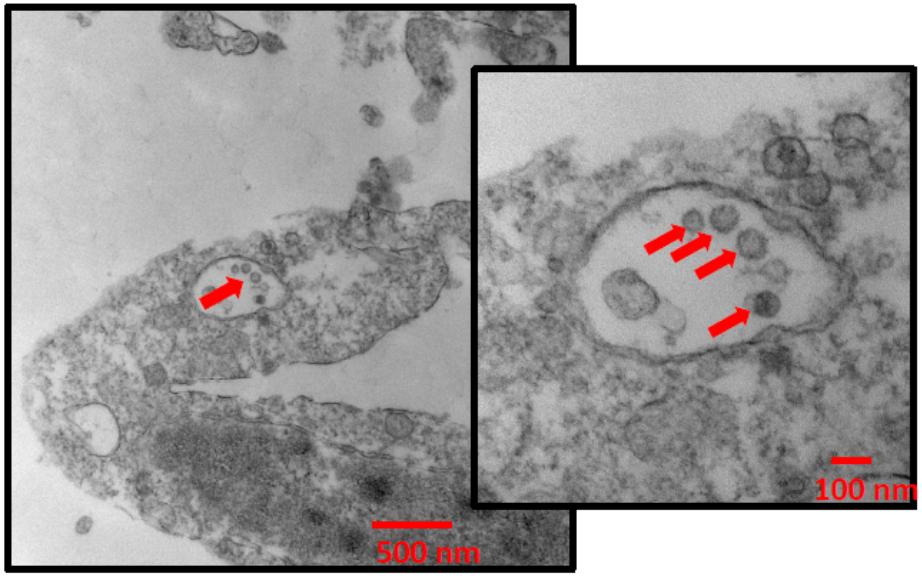


Figure 3. Electron micrographs of SARS-CoV-2 virions cultivated from the sub-micron filter from Room 5C.

Isolation of SARS-CoV-2 from the air in a car driven by a COVID patient with mild illness

John A. Lednicky,[1,2] Michael Lauzardo,[1,3] Md. M. Alam,[1,2] Maha A. Elbadry,[1,2] Caroline J. Stephenson,[1,2] Julia C.Gibson,[1,2] and J. Glenn Morris, Jr.[1,3*]

ABSTRACT

We used a Sioutas personal cascade impactor sampler (PCIS) to screen for SARS-CoV-2 in a car driven by a COVID-19 patient. SARS-CoV-2 was detectable at all PCIS stages by PCR and was cultured from the section of the sampler collecting particles in the 0.25 to 0.50 μm size range.

Title: Development of a Coronavirus Disease 2019 Nonhuman Primate Model Using Airborne Exposure

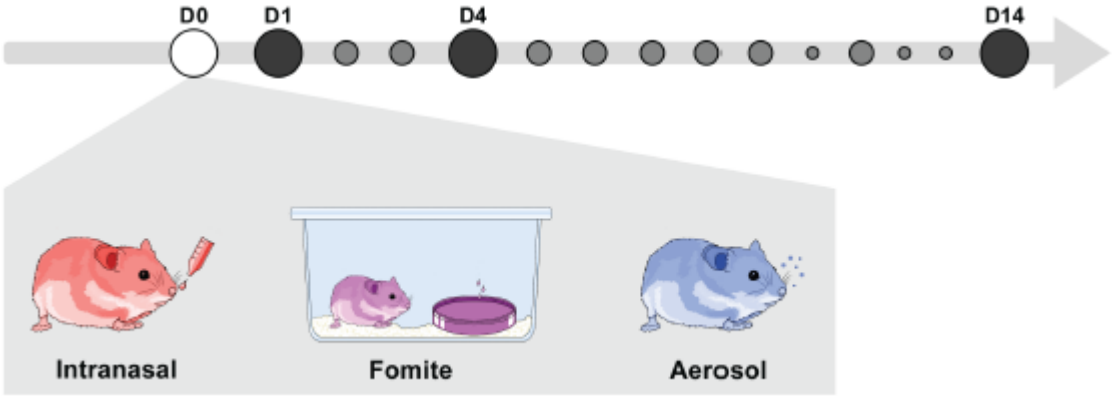
Authors: Sara C. Johnston[1*], Alexandra Jay[2], Jo Lynne Raymond[3], Franco Rossi[4], Xiankun Zeng[3], Jennifer Scruggs[3], David Dyer[4], Ondraya Frick[4], Joshua Moore[2], Kerry Berrier[4], Heather Esham[4], Joshua Shamblin[2], Willie Sifford[2], Jimmy Fiallos[2], Leslie Klosterman[2], Stephen Stevens[2], Lauren White[2], Philip Bowling[2], Terrence Garcia[4], Christopher Jensen[4], Jeanean Ghering[4], David Nyakiti[4], Stephanie Bellanca[4], Brian Kearney[5], Wendy Giles[2], Nazira Alli[4], Fabian Paz[2], Kristen Akers[5], Denise Danner[5], James Barth[5], Joshua A. Johnson[5], Matthew Durant[5], Ruth Kim[5], Margaret LM Pitt[7], Aysegul Nalca[6*]

CMs have been investigated as a potential model for SARS-CoV-2, with variable disease 20 findings noted following either IT/IN or IT/IN/ocular inoculation (*11, 22*). Importantly, fever, which represents a prominent human disease sign and which was consistently noted for CM on the present study, was not noted for any CMs on these prior studies.

(1 -3 µm)

SARS-CoV-2 disease severity and transmission efficiency is increased for airborne but not fomite exposure in Syrian hamsters.

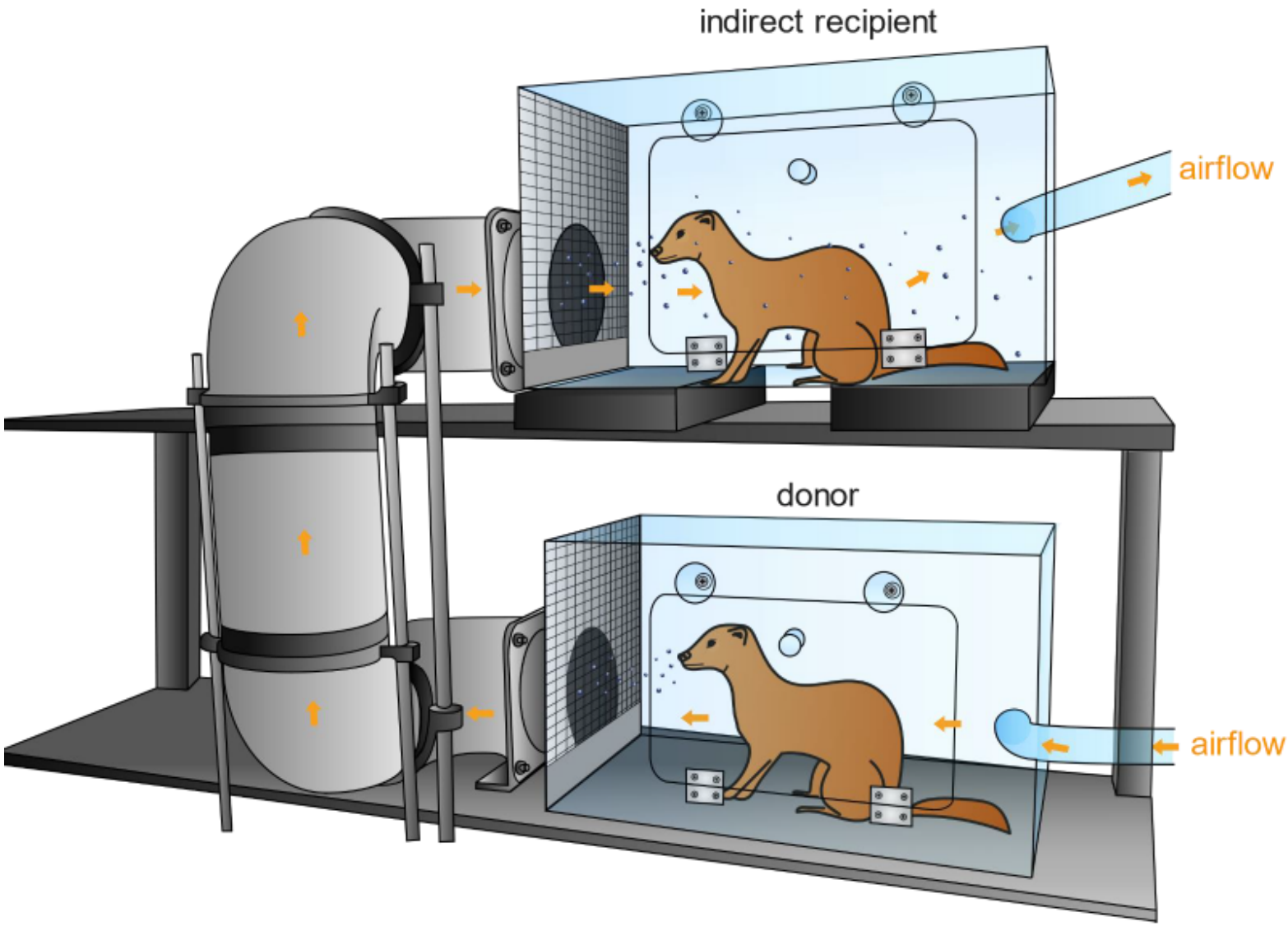
Julia R. Port[1*], Claude Kwe Yinda[1*], Irene Offei Owusu[1], Myndi Holbrook[1], Robert Fischer[1], Trenton Bushmaker[1,2], Victoria A. Avanzato[1], Jonathan E. Schulz[1], Neeltje van Doremalen[1], Chad S. Clancy[3], Vincent J. Munster[1#]

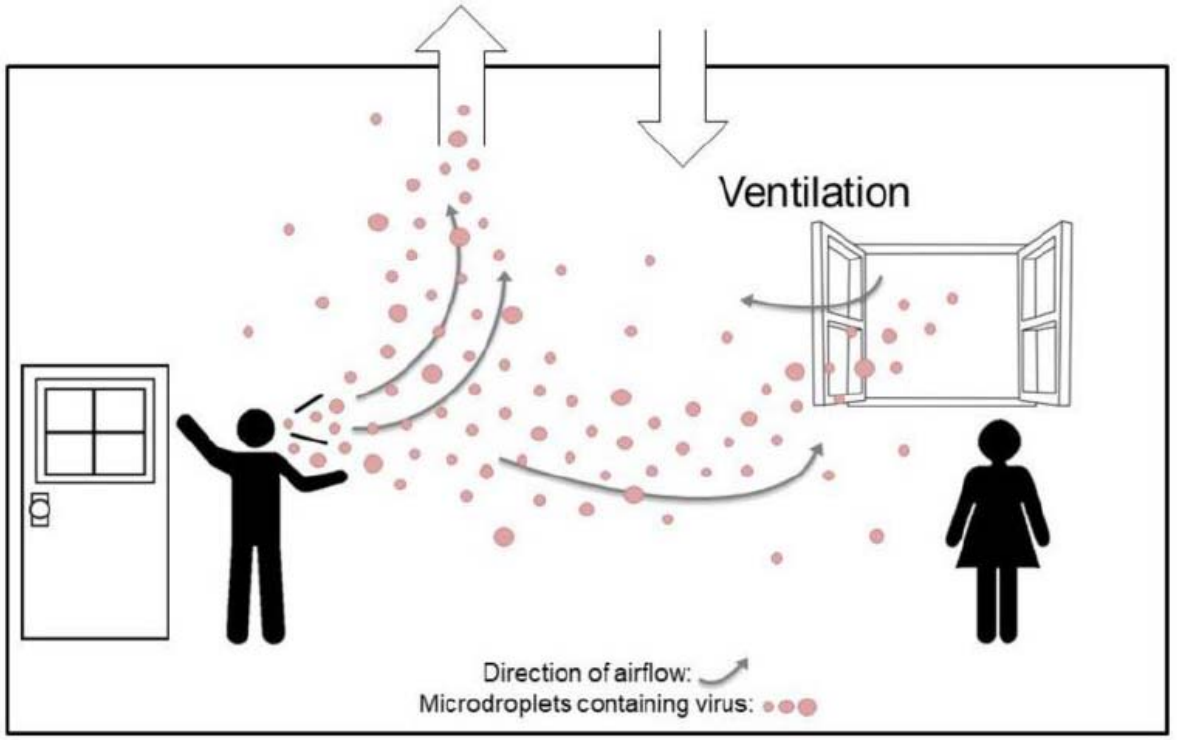


Aerosols of 1 -5 µm

"Intranasal and aerosol inoculation caused more severe respiratory pathology, higher virus loads and increased weight loss. Fomite exposure led to milder disease manifestation characterized by an anti-inflammatory immune state and delayed shedding pattern."

Figures





Morawska L
Milton DK
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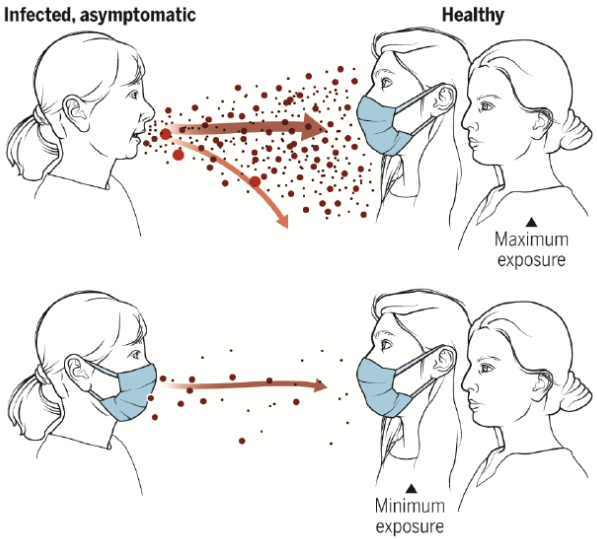

Prather KA et al Science May 27 2020

3M

https://blogs.cdc.gov/niosh-science-blog/2017/07/06/elastomerics/