Note 6. Those viruses are airborne. Human-human contacts are ONLY part of transmission – focusing on this misses many points. Are surfaces relevant?

Of course, with highly deadly viruses, it is logical to avoid transmission, and many viruses actually do need personal contacts to infect, one can think about STD (Herpes, HIV, even some but not all hepatitis…), think about hemorrhagic fevers (Ebola, Lhassa, Marburg, Yellow fever…).
But many other viruses do not need personal contacts only.

Viruses may kill fast and in great numbers and then cannot infect many, or they can infect many very fast and then they are not the worst 'killers'.

This does NOT mean that SARS-CoV2 and the disease we see (COVID19) are benign or not dangerous, **like it was announced by some**. But the viruses we are dealing with here are not effective **direct** killers. Nevertheless they are dangerous and still pose a major public health threat that has to be dealt with. Spreading the opposite view is irresponsible.

All those viruses (cold, flu…) are also AIRBORNE, which means that human-human contacts are the *major* but *only* a part of the problem. Viruses are so small that they weight essentially 'nothing'. They are not only present in cough droplets but also exist as individual particles on their own - in incredibly huge numbers. This means that they do not need humans, airplanes or ships to travel the world. Like dust and small sand particles, they are lifted by winds, and **any** atmospheric disturbance. Viruses can then be carried thousands of kilometers away in the upper atmosphere, before being deposited back onto the Earth's surface. A virus may take only a couple of days to make the trip Sidney-Brussels, no human needed! This is not a hidden secret knowledge; it has been studied for many years, as even vulgarization papers exist. *"Every day, more than 800 million viruses are deposited per square meter above the planetary boundary layer"* to quote an article published in a magazine in January 2018 (Science Daily – 2018) and also see (Reche et al, *ISME Journal* 2018).

Hence when papers in reputable journals like Nature title in bold that experts are disagreeing on this, it does not help (see Nature, Lewis April 2020). Experts cannot disagree on chemistry and biophysics – as this is what the airborne question is about - but can disagree about the **risks**. When the WHO states that there is not sufficient evidence, they emit an opinion, they do not say that viruses do not fly; they try to state that the chances of getting the disease are low. Experts would agree on this, but it is not the same as saying that the virus is NOT airborne. Once airborne however, contact tracings become much less useful (as Sweden logically decided – see Note 9).

This has been widely studied by many scientists and for many viruses even larger than CoV2 like the Flu (See Nikitin et al, *Adv. Virol*). When one person is infected – even without coughing – one shed viral particles by the millions with each breathing cycle (this is called tidal – or normal – respiration). Coughing, sneezing, talking and breathing generate clouds of airborne particles with different sizes between 1 and 50 micrometers, the largest being even in the millimeter range. Large droplets (above or at 10-50 microns) fall and settle on the ground quickly in minutes (like within less than 2 m distance). Small particles (like 10 microns) can stay airborne for hours and can be inhaled deeply by any other persons. **Studies with the flu showed that 99% of exhaled particles were smaller than 5 microns** (Nikitin et al)**. [Remember that the flu is even larger than the Coronaviruses!]**

About the Coronavirus, the WHO (see NPR org ref.) and others (see Wired magazine ref.) tried to educate the public about this. Transmission routes from a person to another happens through direct or indirect contact, droplets (e.g. when sneezing) and through airborne routes (e.g. normal breathing or from the air). This is true for all airborne viruses *including* coronaviruses (with evidence suggesting aerosol transmission and thus infection for the Severe Acute Respiratory Syndrome coronavirus SARS-CoV 1

outbreak of 2003, as well as Middle-East Respiratory Syndrome-associated coronavirus MERS-CoV outbreak of 2012) (*Kutter et al., 2018; Yu et al., 2004; Tellier et al. 2019; Booth et al., 2005*).

Now it is obvious that the doses – that is the number of particles – that one inhales is lower from the air than when being exposed to sneezing and coughing. Depending on the winds, the walls, the layout of a space, one can get higher or lower concentrations of those airborne viruses, and hence we can breathe the particles but usually without becoming sick. Sometimes we do. Most viruses can infect (*Tellier et al. 2019*), although the chance of getting sick is lower, one gets enough particles to get immunized, as the immune system works best at very low doses. There were early (February 2020) a few reports labeled by the press as "mystery cases" as they showed no trace of contamination by any contact – those were NOT so mysterious, they are part of what is called 'community' infections. Lots of people without having being even sick may have gotten the virus and have already safely immunized themselves (see numerous independent data about this crucial point in the Note 9 Statistics). This airborne element is what convinced Sweden to NOT fight human-human contacts, as it would no longer be useful anymore [See Note 9]. Once the virus is in the air, tracing it via contacts becomes useless.

Relatively little is known of the number of viral particles that are necessary for a major infection. However, evidence shows it depends on the type of virus and various other parameters (environmental…) and can range from as few tens of particles (in the case of a Norwalk virus) to thousands of particles for others (*Teunis et al., 2008; Nikitin et al., 2014*).

It is mostly the environmental biologists who study and understand the ecology and the spread of viruses. In a recent paper (see Morawska et al. 2020), we can read the following:
[quote] "Still Despite the evidence and strong hypotheses, the world appears to be locked in the old way of thinking that only direct contact matters in viral infection spread. It is disconcerting that with all the experience and evidence currently available, when faced with a new viral outbreak of COVID-19, the authorities still fail to acknowledge the airborne pathway of transmission, although many experts in China and other countries have had experience in dealing with SARS". No comments needed…

Hence, in closed spaces (such as healthcare facilities or a cruise ship for example), airborne infection is a true threat (*Chughtai et al., 2019; Jones and Brosseau, 2014 and 2015*).

Some of the medical procedures that are used in hospitals (intubation, setting up respirators…) are generating very high aerosols concentrations that are sufficient themselves to transmit infections. Endotracheal intubation, in particular, has been shown to result in significant risk of nosocomial SARS infections at least by a factor of 3 (with an odds ratio of 2.8, see Fowler at al.). [Note: "Nosocomial" means originated in hospitals]. Here both medical personnel and the intubated patients (without any SARS virus at first) may be infected as a consequence of those procedures inside the closed air system of the hospital. Another study done in Honk Kong evidenced also that long-range viral airborne transmission was a problem in an ICU (See Xiao et al, role of fomites in PLOS One 2017), others confirmed this problem too (Booth et all, 2005). (Note: Fomites are surfaces that can be contaminated and dangerous)

What role can various surfaces and materials play in the liveliness of the virus? And can it be a major source of human infections?

No one has any valid statistics about people being infected from touching surfaces.
So everything that has been written and said are opinions, based on a certain common sense. Studies exist for hospitals and in the health care worker community – and there it is obviously relevant.

While this question about surface viability may sound like an adequate question, given the fact that most of the viral particles are airborne, it is not highly relevant outside of the professional settings. Sometimes what *seems* clean is *not* clean and vice versa. For example plastic and metallic surfaces that are visually 'cleaner' are in general less safe than, say, a dirty wooden plank in a butcher shop. This has been shown numerous times by bacteriologists, as wood contains tannic molecules (tannic acids = antiseptics) and has a more complex surface than plastic/metals. (see Nese et al, 1994).

It is known that the flu (both Influenza A and B) can survive for 1-2 days on steel and plastic, but only 8-12 hours on cloths, papers and tissues (Bean et al., J Inf. Dis. 1982). What is very important to note is that one can get the virus transferred from these surfaces but the virus did not survive more than 5 minutes on the hands. This without ANY disinfectant – our skin protects itself, due to its pH and porosity. So cleaning hands and keeping hands clean surely helps a lot. Soap vs. disinfectant? Alcohol-based hand sanitizers while getting rid of the viruses, do not kill off Noroviruses, and E. coli – soap does.

The aerosols and the surface stability of SARS-CoV2 were studied (see Van Doremalen et al. in NEJMed. 2020). While it is interesting to confirm that cardboard are safe, and copper surfaces are safe too (copper is a known antiseptics), it neglects the consequences of the virus being airborne. As explained microbes – like dust - can in open spaces travel thousands of kilometers (see *Yahya et al., 2019* for a study in the Red Sea region).

A highly relevant question is what role does the surface of medical filters play – as it directly impacts the health care workers (see Chugtai, 2019)? Airborne respiratory viruses may settle on the surface of used masks layers, resulting in contamination. Virus (adenovirus, RSV, flu) could reliably be measured and, shown to lead to self-contamination, especially with longer use (like > 6 hours, Chugtai).

Those facts have serious consequences that have been overlooked:

1. Do we really need to disinfect all the surfaces outside hospitals? Lots if not most SARS Virus particles stay airborne.
2. Why are we making our life harder by wearing masks that will NOT stop viral particles (see Note 8 about mask)?
3. We should indeed protect health care workers, and actually lots of good work have been done for years fighting SARS-CoV1 and have led to very valuable recommendations (see the 4 references from Fowler/Xiao/Booth and Brosseau among many).
   The CIDRAP (Brosseau) is a highly educating reference written for a general public.
4. Why aren't we not putting filters where needed ? In aeration/ventilation/HVAC systems instead of the noses of whole populations?
5. Never forget that what is useful to protect health care workers may be of very dubious uselfulness to protect the citizenry. Human contacts are a much more important risk for health care workers than for the average person.

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