The infection risk of SARS-CoV-2 is greatly reduced by antigen point-of-care testing and masking

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In the Northern Hemisphere, the SARS-CoV-2 pandemic has been successfully contained in some countries, at least temporarily, although the current variants of concern are more infectious. For the example of Germany, the change toward a slowdown in the rate of infection coincided with an increase in temperature and sunshine duration, but also with a massive rollout of rapid antigen testing, i.e., AG-PoC (antigen point of care) as part of the national testing strategy with one free test per week for every citizen. The large-scale introduction of Ag-PoC testing occurred in parallel with a steady rate of vaccination and a continuation of other public health interventions such as social distancing, mask wearing, contact tracing, and quarantine. The purpose of this viewpoint is to assess the risk of infection in individuals who tested negative by AG-PoC. The operating principle of AG-PoC testing is to break chains of infection by identifying asymptomatic or presymptomatic infected individuals, assuming initiation of quarantine of individuals who test positive by AG-PoC, in addition to contact tracing. Due to the lower sensitivity of AG-PoC, the diagnostic interval is shortened compared to the gold standard of PCR. However, the diagnostic window correlates with the phase of highest infectivity. One issue to consider in this context is the limit of detection (LOD) of commercially available Ag-PoC kits. Literature review gives a range for LOD of 10^4 to 10^6 viral copies/mL of exhaled fluid [see for example 1]. While the typical viral load for the alpha variant is $10^{8.5}$ [2]. This suggests that with AG-PoC and the application of quarantine to identified individuals, the viral load in the general population is reduced by a factor of up to 10,000 or more for the delta variant. It should be noted that similar effects are also expected for vaccinated individuals in case of infection, although the range for the viral load are yet to be known.

Table. Upper bound for individual's infection risk in percent after 1 hour for *near-field* and *far-field* exposure. Near-field considers a breathing-only susceptible in exhalation cloud of a speaking infectious. *Far-field* considers a classroom with 30 pupils and a speaking infectious teacher.

Scenario	**Viral load [copies/mL]**		
	10^4	**10^6**	**10^8**
Near-Field			
No masking at 1.5m	0.30%	26%	99.99%
Susceptible surgical-mask-protection at 1.5m	0.01%	1.2%	71%
Susceptible FFP2-protection at 1.5m	0.0008%	0.08%	8%
Both surgical-masking at point-blank range	0.001%	0.1%	10%
Both FFP2-masking at point-blank range	0.00001%	0.001%	0.13%
Far-Field			
School, 180m^3, teacher infectious, pupils 15y	0.0014%	0.14%	13%
School, 180m^3, teacher infectious, pupils 15y, 4 ACH	0.0008%	0.08%	7%

What are the implications of this?
The table shows an overview of the risk of infection of a recipient after 1 hour of exposure to the virus-laden aerosols, with an initial wet droplet diameter of <50µm for different situations, estimating the upper bound for the risk of infection when the susceptible and the infectious are in close proximity to each other (near-filed) or when both are in a *well-mixed room*, where it is assumed that the infectious aerosols mix homogeneously and instantaneously into the entire volume of the room (far-field). While the near-field case considers exposure from the infectious person's exhaled cloud, the far-field case indicates the risk typically expected in, for example, a classroom environment where a possibly infected teacher is at a distance larger than 1.5m from the students. The calculation of risk follows Bagheri et al. [2] and Nordsiek et al. [3] and uses the Human Emission of Aerosol and Droplet Statistics (HEADS) database, available at aerosol.ds.mpg.de, for the well-mixed classroom type situation. The table also considers the effect of face masks and expected typical leakages, as described in Bagheri et al. [2]. It is assumed that the infectious person speaks at a normal voice-loudness, is 35 years old, and that the susceptible breathes normally. In the classroom situation, there are 30 unmasked students in the room aged 15 years breathing normally while the unmasked infectious 35 years old teacher is speaking with normal voice-loudness for 1h. For the classroom the case of no air-exchange and a 4 times per hour air exchange (4ACH) are considered. The table gives the risk of infection for a susceptible depending on the viral load of the detection limit of the AG-PoC tests (shaded yellow) and a typical viral load of the SARS-CoV-2 virus. A dose of 200 virions was used in the calculation for a likelihood of infection of 63.21%. It can be seen for viral loads for an estimated LOD of AG-PoC kits are much reduced and with it the risk of infection. For a viral load of 10^6 copies per mL only direct exposure without masks is highly elevated. For the highest viral load considered here, i.e. 10^8 copies per mL, which is already below the mean viral load [2] of the alpha variant, any exposure is associated with considerable risk of infection.

These calculations show that for persons with a negative AG-PoC test, the risk of disease transmission by aerosols is greatly reduced even without wearing masks. If the LOD would be 10^4 copies/mL, or better, mask wearing might not be necessary at all for aerosol transmission. However, it must be emphasized that this analysis does not account for infection by >50µm droplets that become dominant at short distances without masking. It is particularly clear that even extensive testing can reduce the risk of infection (in addition to vaccination campaigns) and significantly reduces the added value of mask wearing in many everyday situations.

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