Covid-19 contagion via aerosol particles comparative evaluation of indoor environments with respect to situational R-value

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Introduction

To assess the risk of infection via aerosol particles in enclosed spaces, the inhaled dose is important.
The dose depends on:

- source strength (emission rate)
- breathing activity (source and receiver)
- aerosol concentration in the room
- duration of stay in the room

With a mask (mouth-nose protection/mouth-nose cover) the aerosol emission as well as the quantity of inhaled particles can be reduced. Breathing, speaking, singing, etc. influences the number of exhaled particles. The respiratory activity, e.g. breathing, speaking, singing etc., as well as the physical activity influence the number of exhaled particles and the quantity of inhaled particles by healthy persons. The air supply into the room regulates the number of aerosol particles in the air (concentration) and finally the duration of stay results in a quantity of particles inhaled.

Comparative evaluation of indoor environments

The assessment of the absolute risk of infection via aerosol particles is not sufficiently evidence based. However, the dose can be determined very well. Therefore, known data for the respiratory volume flow for different activities [1-3], emission rates [4-8] and from relevant standards and guidelines [9-11], regarding the ventilation of indoor environments, the person-related supply air volume flows for rooms with different use, can be used. For the duration of stay in indoor environments typical values for the usage can be taken.
In addition, in the following comparison, it was assumed that the user complied to the German AHA+L[1] rules as well as the recommendations of the BAuA[2] and the UBA[3] [12,13].
The use of a cotton mask (mouth-nose cover) or a medical mouth-nose protection of untrained personnel has an overall filter efficiency of 50% [14]. It consists of a reduced emission rate of the infected person and the filter performance during the inhalation of the

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[1] AHA+L stands for distance, hand hygiene, mask + ventilation and recommends a distance of 1.5 to 2m
[2] German Federal Institute for Occupational Safety and Health
[3] German Environment Agency

healthy persons. Even if this assumption is incorrect, it will in the comparative evaluation just influence the cases, where a case with a mask is compared to a case without a mask.
In the following evaluation it has always been assumed, that an infected person stays in the room together with other healthy persons. The probability that an infected person is in the room at all, has not been considered.
Figure 1 shows different types of use/indoor environments. In each case, x-times the risk relative to a situational R_S-Wert ≤ 1 is given. The calculation of the R_S-value can be derived from [15]. The R_S-value means the number of infected persons if an infected person is present at the same time. Even if the calculation of the R_S-values is not sufficiently evidence based, it does not play a role in the comparative evaluation. The shown bars would just be moved parallel to the left or right.

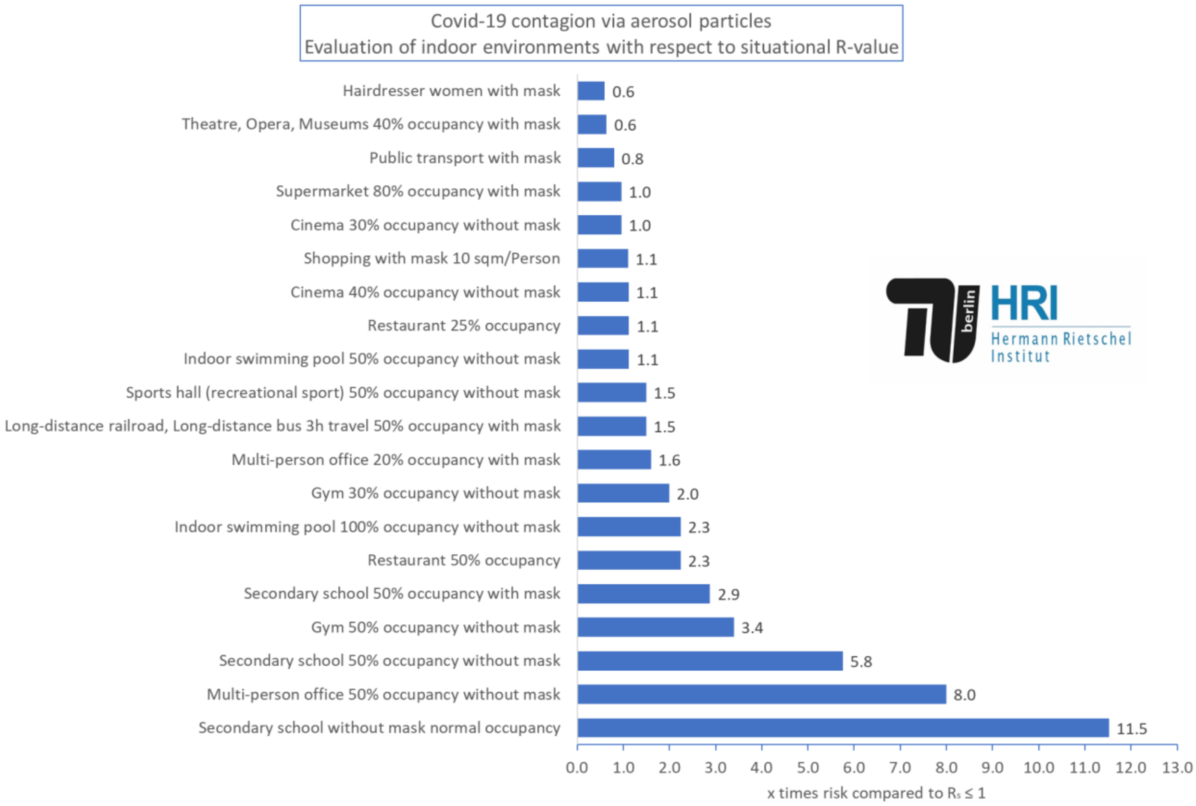

Figure 1: Comparative presentation of typical indoor situations

Explanation example:
A person with mask in a supermarket has a risk with the value ≤ 1. This means, that in this situation a maximum of one other person will be infected. In comparison a multi-person office with a 50% reduced occupancy, but without wearing a mask at the workplace, has a value of 8. This means, that the risk in this situation is 8-times higher than in the supermarket.
In contrast, a visit to a theater in a meeting place with 30% reduced occupancy and with wearing a mask while sitting is just half as risky as in the supermarket.

The cases in Figure 1 can be extended arbitrary.

Boundary conditions for the comparison made in Figure 1:

Indoor use	Duration of stay in h	Specific supply air volume flow in full load in m³/h/person	Specific supply air volume flow for this case in m³/h/person	Activity level: Respiratory volume flow/ emission rate
Office 50 % occupancy without mask	8	30	60	II
Office 20 % occupancy with mask	8	30	150	II
Secondary school without mask normal occupancy	6	25	25	II
Secondary school 50 % occupancy without mask	6	25	50	II
Secondary school 50 % occupancy with mask	6	25	50	II
Public transport with mask	0.5	20	20	II
Supermarket 80% occupancy with mask	1	25	31	III
Hairdresser women with mask	2	20	40	II
Shopping with mask and 10 sq m/Person	2	20	40	III
Restaurant 50 % occupancy	1.5	20	40	II
Restaurant 25 % occupancy	1.5	20	80	II
Theatre, Opera, Museums 30 % occupancy with mask	2	30	100	II
Theatre, Opera, Museums 40 % occupancy with mask	2	30	75	II
Cinema 30 % occupancy without mask	2	30	100	II
Cinema 40 % occupancy without mask	2	30	75	II
Gym 50 % occupancy without mask	1.5	40	80	IV
Gym 30 % occupancy without mask	1.5	40	135	IV
Sports hall (recreational sport) 50 % occupancy without mask	1	30	60	IV
Indoor swimming pool 100% occupancy without mask	2	40	40	IV
Indoor swimming pool 50% occupancy without mask	2	40	80	
Long-distance railroad, Long-distance bus 3 h travel 50 % occupancy with mask	3	30	60	II

Table 1: excerpt from the boundary conditions for the comparative evaluation of indoor environments

<u>Activity level as boundary condition:</u>

The activity influences, besides the emission rate because of breathing, speaking, singing, etc., also the respiratory volume flow and together they influence the exhaled number of potentially virus loaden aerosol particles and the amount of inhaled and potentially contaminated air by the healthy persons [1-8, 15].

I laying, breathing
II sitting, standing, breathing, speaking
III easy physical activity, walking, breathing, little speaking
IV heavy physical activity, sport, little loud speaking

Conclusion:

Based on the infection risk model [15], situational R_S-values for the common stay in indoor environments can be predicted. Because of the dynamics of scientific knowledge regarding the probability of contagion, especially of mutations, a comparative evaluation of indoor environments, taking into account protective measures, is a possibility to evaluate everyday life situations. The bars in Figure 1 will move parallel to the left or the right if the medical evaluation regarding the ability of contagion changes.

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