Human exposure against airborne pathogens in an office environment

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SUMMARY

Airborne exposure has been highlighted during the COVID-19 pandemic as a probable infection route. This experimental study investigates different protection methods at an office workstation, where the concentration characteristics are studied under mixing ventilation conditions. The protection methods were the room air purifier, personal air purifier, face mask, and workstation partition panels. In experiments, the breathing machine, nebulizer, and syringe pump were used to generate an aerosol distribution of paraffin oil in the room. The breathing thermal manikin and the thermal dummy simulated the exposed and infected person, respectively. The concentration characteristics were measured from the manikin breathing zone. The temporal concentration characteristics were measured from zero concentration to steady-state conditions. The study provides insights into the effects of different protection methods for occupational health and safety decision-making for office indoor environments.

KEYWORDS

airborne transmission, air purifier, face mask, partition panel, protection method

1 METHODS

Test cases compare different protection methods at workstations (Figure 1). The measurement time was 1 hour and 40 minutes (6000 s) under the air change rate of 1.7 ACH. This included the concentration increase to a steady-state concentration during 3000-5000 seconds and the averaging of 1000 values with the sampling rate of 1 Hz in steady-state conditions.

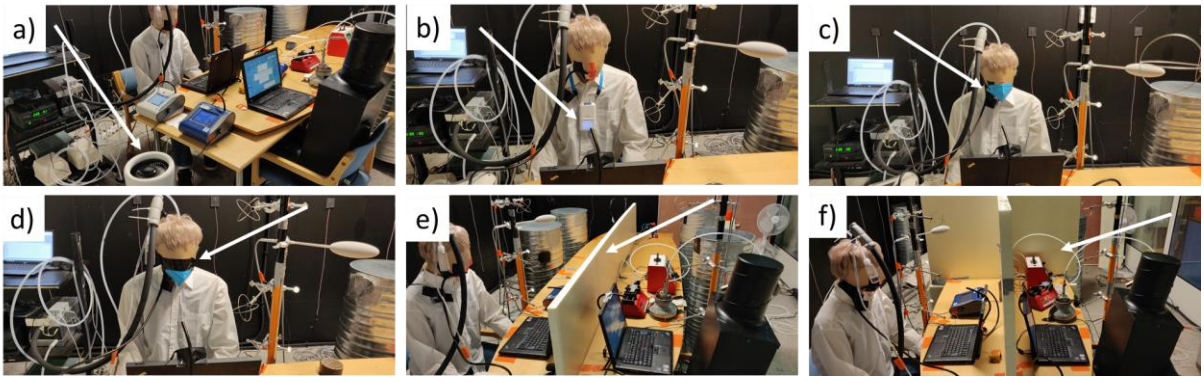

Figure 1: Protection methods: a) Room air purifier on the floor. b) Personal air purifier on the neck (20 cm below the mouth). c) FFP2-mask. d) FFP2-mask, sealed edges. e) Low partition panel on the table in the meeting setup (height 40 cm). f) High partition panels in front and side of workstation extending to the floor (height 80 cm).

The mixed ventilated mock-up room of the office and meeting spaces with internal dimensions of 5.5 m (L), 3.8 m (W) and 3.6 m (H) was used. The infected-to-exposed distance was 1.2 m. The infected person was created by using a respiratory exhalation simulator (CH Technologies Inc.) and a seated thermal dummy including light bulbs and a fan to equalize the heat inside. The seated breathing thermal manikin (P.T. Teknik Limited) was the exposed person.

2 RESULTS

The results at steady-state conditions are shown in Table 1. The concentration level increased to 166±11 μg/m^3 (avg±sd) without any protection method whereas the room air purifier decreased the concentration to 84±7 μg/m^3 and thus reducing the average level by 50%. The personal air purifier reduced the exposure concentration to the level of 137±9 μg/m^3 which means about a 20% percent decrease in the average concentration. As a result, the experiments show evidence that the room air purifier can effectively reduce the exposure at the workstation if the purifier has been optimally designed. Another effective method was the FFP2-mask. The average concentration at the breathing zone falls to 65-103 μg/m^3 meaning from 40% to 60% (sealed) decrease in the concentration level.

Table 1: Averaged mass concentration (AVG) and standard deviation (SD) at the breathing zone of exposed manikin

Parameter	AVG (μg/m^3)	SD (μg/m^3)	reduction (%)
Without protection	166	11	**reference**
Room air purifier	84	7	**-50**
Personal air purifier	137	9	**-18**
FFP2-mask	103	38	**-38**
FFP2-mask, sealed	65	24	**-61**
Low screen:mid table meeting	153	12	**-8**
High screen:mid table meeting	168	11	**0**
High screen:table, mid+side office	165	11	**-1**
High screen:table+floor, mid+side office	154	10	**-7**

The results showed that the room air purifier and FFP2-mask could be a reasonable protection choice against the droplet nuclei aerosols. The room air purifier with HEPA filter effectively reduced the concentration. In this study, the circulating airflow rate was 2.5 times the ventilation airflow rate. The FFP2-mask reduced the exposure, but the user comfort can be poor if used the entire working day. In addition, sealing the face piece by proper fitting is important. The wearable personal air purifier had a relatively low effect on exposure and the location of the purifier seemed important because the clean air jet was narrow. However, it may be effective if the location can be adjusted with a holder, etc. The workstation partition panels had a negligible effect on the exposure. The partition panels may be better against coughing because those prevent droplets to reach other workstations.

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