EDITORIAL

Respirator Fitting Characteristics: The Emerging but Negligent Issues Influencing Optimal Respiratory Protection against New Coronavirus (Covid-19)

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ABSTRACT

According to the hierarchy of hazard controls, respiratory protective equipment (RPE) is considered as the last prevention and control measure against chemical and biological respiratory hazards. However, the correct application of these kinds of personal protective equipment (PPE) as the only control means are inevitably unavoidable during aerosol-generating procedures (AGPs) such as tracheal intubation, noninvasive ventilation, and tracheostomy and so on. Nonetheless, two vital factors influencing the optimal use of RPE are as follows: the filtration efficiency of the respirator and the fitting characteristics of the respirator into the subjects' facial dimensions to ensure the appropriate respiratory protection. It is of utmost importance for HCP, while they are conducting high-risk procedures during emergencies such as the outbreak of the Covid-19.

KEYWORDS: *Respiratory Protection, Fit Testing Procedure, Filter Efficiency, Pandemics, New Corona Virus (Covid-19)*

INTRODUCTION

According to the hierarchy of hazard controls, respiratory protective equipment (RPE) is considered as the last prevention and control measure against chemical and biological respiratory hazards. However, the correct application of these kinds of personal protective equipment (PPE) as the only control means are inevitably unavoidable during aerosol-generating procedures (AGPs) such as tracheal intubation, noninvasive ventilation, and tracheostomy, etc. [1-2]. Nonetheless, two vital factors influencing the optimal use of RPE are as follows: the filtration efficiency of the respirator and the fitting characteristics of the respirator into the subjects' facial dimensions to ensure the appropriate respiratory protection [3].

"Filter efficiency" pertains to the capability of the filter media to capture or filter out the dangerous airborne particles before they enter a person's

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breathing zone and are inhaled. For instance, N95 disposable particulate respirators refer to a group of "air purifying respirators" which are able to filter out at least 95% of the airborne particles, consisting of the most penetrating particle size (MPPS), before they're inhaled by the users, according to the National Institute for Occupational Safety and Health (NIOSH) regulation 42 CFR 84 (4). Also, the FFP2 respirators are a type of RPE which are capable of filtering out at least 94% of the airborne particles with a diameter of 2 to 5 microns before they're inhaled by wearers, according to the EN149 standard [5].

Obviously, N95 respirators or other respirators with higher filtering capabilities (N99 and N100) according to the NIOSH regulation 42 CFR 84 [4] or filtering face-piece respirators (FFRs) with at least 94% filtering efficiency level (FFP2) or even higher level protection such as FFP3 or high-efficiency particulate matter (P100/HEPA) respirators based on the EN149 standard [5], should be worn by healthcare personnel (HCP) during the Covid-19 outbreak to provide them optimal respiratory protection. In addition to the factors influencing filter efficiency, which include particle penetration through the filter material, leakage from around the face-seal (face piece) and the exhalation valves, along with pressure drop (breathing resistance) combine to make up what is called "total inward leakage" (TIL) [5].

Another important factor when determining the efficacy of a respirator is fit. Fit means how well the respirator is fitted to the facial dimensions of the wearer, ideally limiting any leakage occurring between the skin and respirator's face piece, to prevent the workplace's contaminated air from entering into the wearer's respiratory system. Thus, there are several fundamental reasons for conducting respirator fit testing prior to respirator use. These reasons are as follows: 1) poorly fitting respirators can be identified; 2) the chance to provide individual training for wearers regarding the proper respirator donning and doffing procedures; 3) the wearer's skill level with regard to the donning and doffing procedures can be evaluated during the training (6).

Since various subjects come in different face sizes and shapes, it is necessary to conduct fit testing as one of the substantial components of a respiratory protection program (RPP), to assure the appropriate respiratory protection for the users before they enter a contaminated workplace. This is based on the respiratory protection standards [1-7-8]. It is important to note that a respirator with high filtration efficiency but poor fitting characteristics might not provide enough respiratory protection for the wearer to protect against airborne particles such as the respiratory droplets contained in the Covid-19. Although it is imperative to devote major attention to the assessment of a respirator's filter efficiency, the capability of the respirator to fit adequately enough to provide optimal respiratory protection should not be ignored [3].

Fit testing procedures can be categorized into the following; qualitative fit test (QLFT) and quantitative fit test (QNFT). The QLFT is a dichotomous test (pass/fail) which relies on the wearer's olfactory and taste response and uses a challenge agent with a specific taste or odor. The challenge agent can be BitrexTM, saccharin, isoamyl acetate (IAA), or irritant smoke, while conducting a set of simulated fit test exercises. BitrexTM which has a bitter taste and saccharin with a sweet taste are utilized for particulate respirators. Isoamyl acetate (IAA) has an odor like banana oil and is only used for testing half face piece respirators equipped with organic vapor (OV) cartridges, while the irritant smoke with its irritating odor is used for testing respirators equipped with HEPA filters [1-7-9].

Despite the QLFT being based on the subjective reaction of the wearer and the fact that using high volumes of qualitative fit test solutions is expensive and their availability might be scarce during emergency situations [10]; it's a simpler, cheaper, and faster test to perform than the QNFT [11].

The QNFT uses an instrument to quantify the ratio of the concentration of a challenge agent in ambient air to its concentration inside the respirator (fit factor (FF) = C_{out} / C_{in}) while performing a set of simulated fit test exercises. Quantitative fit tests are classified into three common groups as follows: the generated aerosol method utilizes a non-hazardous aerosol (such as sodium chloride or corn oil) which is dispensed into a test chamber. The condensation nuclei counter (CNC) method, commonly named "TSI PortaCount®", uses laser technology to measure aerosol concentrations inside and outside of a respirator equipped with a sampling adaptor, without a test chamber.

Lastly, the controlled negative pressure (CNP) method of QNFT warrants that a fixed vacuum is created on the facepiece with special adapters that measure the airflow or leak rate. Although this kind of fit testing is expensive and it requires some modification (e.g., sampling adaptors or probes), experienced administrators, and annual equipment recalibration [1-7-9], it does have some advantages, such as the documentation of the numerical results [12], optimization of the training and real-time fit factors, and reduction of the operational resources [12].

Various criteria influence the selection of respirator fit testing procedures. These include the wearer's ability to detect the challenge agent, the suitability of the fit testing procedure for the proposed respirator, the cost and benefits of the fit testing procedure, and the compliance with regulatory standards [13].

Overall, none of the fit test methods are free of error; therefore, their inherent errors could cause poorly fitting respirators to be worn in a contaminated workplace by the wearers [14]. As mentioned previously, in addition to a filter's efficiency, the respirator's fitting characteristics should be considered for all workplace jobs whether they be in industrial, clinical or public settings. It is of utmost importance for HCP, while they are conducting high-risk procedures during emergencies such as the outbreak of the Covid-19, that they have a highly efficient and well-fitting respirator to protect them from contracting respiratory infectious diseases.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

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