Washing hands and the face may improve protection in COVID-19

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Respiratory viral transmission routes include: large droplets generated by an infected person's cough impacting on susceptible individuals and fomites, fine particle aerosols generated during physiological breathing, by touching contaminated surfaces followed by hand to facial mucosa contact, and potentially via fecal to oral or nasal transmission [2,3]. Although the relative importance between these modes of infection is highly variable with many unknown, we may guess that the final respiratory virus inoculation step occurs via nasal inhalation of virions from the surrounding air or contaminated face. How virions are transmitted from the contaminated face to respiratory mucosa remains unknown.

Because viruses can survive on fomites for a prolonged period of time [5], susceptible individuals can also contaminate their hands and then deposit the viral particles on their faces. If there are no viral aerosols in the air surrounding the susceptible person, the only viral source is located on the subject's face, previously contaminated by his hands.

Recent human behavioral observation studies reported that on average participants touched their faces between 17.8 and 23 times per hour [7,8]. Of all face touches, approximately 42-44% involve contact within the proximity of a mucous membrane, **Figure 1a**. The viral particles in proximity to the nostrils experience periodic reciprocal inhale/exhale convective flows and a shear stress.

In the ongoing SARS-CoV-2 prevention campaign the main advice is to wash hands and not to touch one's face. Adults seldom insert fingers into the nose, so how does the virus find its way from the contaminated face to the nasal and respiratory mucosa? Moreover, what is the area from where the virus can enter the nose during normal breathing?

Simulation of Viral Particle Re-Transmission form the Face to the Nose during Inspiration.

To answer the above questions, we conducted 3D CFD simulations of the air flow into the human nostrils during the inhalation period. A 3D anatomic geometry of a human face is used with two nostrils identified as inhalation flow boundary condition regions. A 3D box of the air surrounding the human face is used as a simulation domain.

The goal of our simulations is to determine the spatial distribution of wall shear stresses on the human face around the nose. It has been well documented that wall shear stress is directly related to particle resuspension from a surface into the flow stream [10]. Figure 1b shows the flow velocities close to the nostrils and contour maps of the wall shear stress, $\tau=\mu*du/dn$, on the face for a physiological berating flow rate of 30 L/min. The highest shear stresses are located directly under and inside the nostrils. The facial area from where the viral particle can resuspend depends on the particle and facial skin physical status. Once resuspended from the skin, the small virion particle will almost certainly enter through the nostrils into the lungs. Quantitative prediction of the viral particle resuspension is theoretically possible but would require experimental data for model calibration [10].

The results presented here indicate that part of the human face close to the nostrils could be a source of viral self-inoculation. The amount of inhaled viral load depends on the accumulated facial surface coverage of particles and on the breathing flow rate. We believe that similar to hand washing, periodic cleaning of the facial area, shown in Figure 2b could prevent viral self-infection.

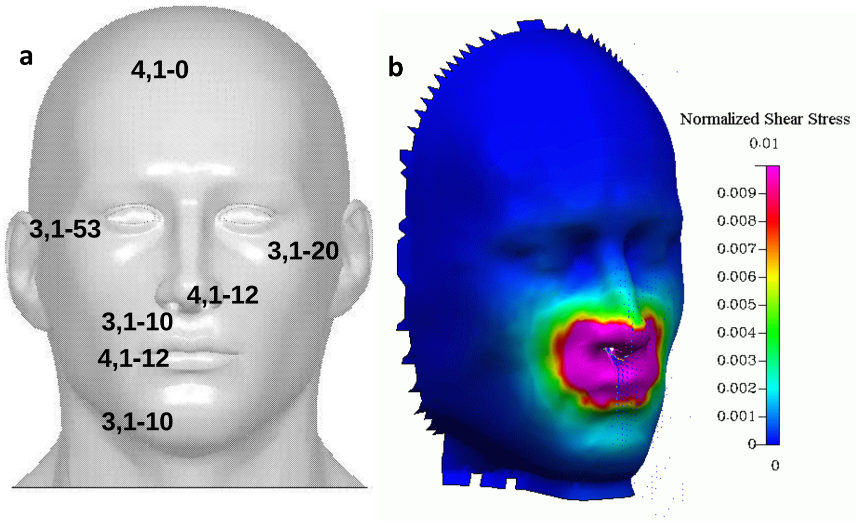

Figure 1. a) Anatomical distribution of number face touches and duration time range observed in a one-hour period [7], and b) Predicted contours of nondimensional wall shear stress, τ, on a human face during physiological air inhalation

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