The Potential for Screening and Tracking of COVID-19 Using Particle Counters, Version 2

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We are in search of new methods for identifying COVID-19 cases and tracking the progression of their disease. Here we discuss particle counting technology as a potential means. Comments and engagement are welcome.

The size of encapsulated SARS-2 coronavirus particles responsible for COVID-19 is $0.060 - 0.140\mu$ $(60 - 140\text{nm})$ [1], [2]. In exhaled breath, it is often attached to particles of respiratory secretions [3] that have a peak in their size distribution at $1.0 - 1.4\mu$ [4]. The presence of particles at that size is distinctive due to a gap in the particle size spectrum in ambient air [5]. The changes in the lung tissue due to infection, as well as the process by which viral particles are launched into the air may significantly affect the size of particles exhaled. Existing technology may be capable of distinguishing the presence of the viral particles, the change in particles they are attached to, or more generally the change in particles that are being exhaled.

Particle counters, including optical particle counters, aerodynamic particle size spectrometers and other devices are commercially available to count the number of particles of sizes ranging from $0.3 - 10\mu$ at various levels of resolution, i.e. 2 bins, 12 bins, or 1024 bins. More specialized equipment, such as Scanning Mobility Particle Sizer, and Laser Aerosol Spectrometers, can extend this range down to 0.090μ, enabling them to count isolated viral particles if they are present individually in exhaled air, and may include other diagnostic features such as luminescence detectors to determine bioactivity. At the size of the viral particles, other particles are more abundant, so there is a need to distinguish them from the background.

Both standard particle size counters and more specialized equipment should be tested for their ability to provide a clear signature and quantitation of the density of viral particles in the breath of individuals that are or may be infected by the coronavirus responsible for COVID-19. The signature may provide indication of the presence of infection, its severity, or the degree of infectiousness, which may vary across the course of an infection. Challenges to developing a distinctive signature include individual variability in particle size distributions [4]. Nevertheless, distinctive features may be identified at least with higher resolution observations. The opportunities that such a characterization would provide should motivate rapid inquiry and determination of its potential.

The importance of particle count testing is to provide (1) screening of individuals for isolation in the absence of sufficient PCR testing, with symptoms or potentially even before symptoms arise (2) screening individuals for participation in economic activities, (3) monitoring the effect of interventions to improve health outcomes, including both pharmaceutical and non-pharmaceutical interventions, (4) screening of travelers for 14 day quarantine, (5) developing a better understanding of the progression of the disease in an individual as well as across the population.

Oxygen masks may be used for sampling breaths. However, for rapid sampling from multiple individuals without cross contamination alternative sampling methods should be tested. In particular obtaining samples of breathed air without direct contact may be achievable by having an individual breathe into a plastic bag, and suctioning the air into the device. This enables multiple individuals to rapidly perform tests, perhaps even multiple per minute, for a rate of many thousands of tests per day per device. Particle counters are available from multiple manufacturers and it is important to ramp their production if the ability to obtain a clear signature is confirmed by initial testing. Initial testing consists of taking samples from individuals with and without symptoms, including individuals who have tested positive.

References

[1] Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. (15 February 2020). "Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study". The Lancet. 395 (10223): 507?513. doi:10.1016/S0140-6736(20)30211-7. PMID 32007143.

[2] N. Zhu et al, N Engl J Med 2020; 382:727-733, DOI: 10.1056/NEJMoa2001017

[3] Otten, JA, Burge, HA (1999). Viruses. In J. Macher (Ed.), Bioaerosols: Assessment and control (pp. 1?6). Cincinnati: American Conference of Governmental Industrial Hygienists.

[4] Papineni, RS and Rosenthal, FS, The size distribution of droplets in the exhaled breath of healthy human subjects. Journal of Aerosol Medicine 10.2 (1997): 105-116.

[5] W. Birmili, K. Heinke, M. Pitz, J. Matschullat, A. Wiedensohler, J. Cyrys, H.-E. Wichmann, and A. Peters (2010), Particle number size distributions in urban air before and after volatilisation, Atmos. Chem. Phys., 10, 4643?4660, 2010 doi:10.5194/acp-10-4643-2010