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Sars-Cov-2 Kinematics and Physical Distance to Prevent Infection

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Abstract: The SARS-CoV-2 virus, which causes COVID-19 disease, has a spherical shape between 100 and 200 nanometers (nm) in diameter and weighs more than 100 attograms (ag). It very compact molecular structure (composed of proteins, aminotraspheres, lactic dehydrogenase, procalcitonin) makes it very sensitive to terrestrial gravitational attraction, whose weight is increased by the high adherence of water from atmospheric humidity and other chemicals. The World Health Organization (WHO) recommends maintaining a minimum distance between people of 1 m, while other agencies such as the Centers for Disease Control in the United States recommend 2 m. The objective of the present work was to determine the trajectory or displacement of SARS-CoV-2 and to estimate the maximum horizontal distance reached once it is released from the contaminating focus (nose, or mouth of the person) of the emitting entity towards the fluid field of the atmospheric air, as well as to estimate the sedimentation time, in order to formulate recommendations to avoid direct infection. For this purpose, a simplistic and, at the same time, conservative mathematical model was proposed, which ignores the size of the saliva drops, based on the theory of projectiles launched from above into the fluid field of the atmospheric air under normal conditions. The results show that the trajectory of the coronavirus is a two-dimensional semi-parabola of second degree with a concave descending branch downwards and apex in the focus of contamination (nose, mouth) of the emitting entity. It was estimated that the horizontal maximum ranges are between 0.90 and 1.80 m, depending on the initial speed, and that sedimentation times vary between 5 and 10 seconds. Therefore, it can be concluded that the minimum distance between people, to avoid direct contamination, is approximately 2 m.

Key words: coronavirus, sedimentation time, maximum horizontal range, contagion, atmospheric air viscosity

1. Introduction

How difficult, because it is unusual, to enter a tiny but immense microcosm imperceptible to human sight and all this immersed in the immensity of the vast fluid field formed by the atmospheric air that surrounds us that we also do not see and whose actions and reactions we only feel. These conditions force us, on the one hand, to adopt a system of measurement and units different from those used for big things in order to perceive the magnitudes of the microcosm and the use of non-dimensional numbers so as not to depend on the size of things, and on the other hand, the knowledge of physical and analogical laws, systemic fractal structure to decompose and compose the whole, conceive the continuity of matter and use scales opposite to those used for macro matter, finite differences for the infinitesimal and, of course, great imaginative power to conceive the integration of the relative whole. With all these powerful tools, we can visualize the dreaded SARS-CoV-2 coronavirus that paralyzed the world with an almost stony structure because it stored a large amount of proteins, a diameter that varies between 100 and 200 nanometers and a weight of more than 100 attograms. This weight is increased by the high potential of water from atmospheric humidity and other chemical substances to adhere, making it about 100 times heavier than the molecule of atmospheric air and, therefore, very sensitive to precipitation by the attraction of the Earth's gravity.

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2. Methodology

2.1 Conditions of the Study

- Continuous and isotropic fluid field of the atmospheric air with respect to temperature
- Two-dimensional vertical movement, replicated in parallel planes.
- Normal conditions for atmospheric air: one atmosphere of pressure and 15°C of temperature.
- Estimation of coefficients of forces that delay movement due to the effect of air viscosity under normal conditions.
- Analogy "kinematics of projectiles launched from above and falling bodies" in a viscous fluid environment and attracted by the terrestrial gravitational action.
- Aerostatic state of atmospheric air (air at absolute rest); which implies that under aerodynamic conditions of high fluid turbulence (turbulent flow), the results of this study are not valid.
- The results will only be valid for closed environments and open areas where calm air conditions prevail.

Newton's laws of physics were used which, together with the principles of analogy and nanotechnology, fractal structure and continuity of matter, helped to explain the kinematics of SARS-CoV-2, all thanks to its goodness of offering great sensitivity to the terrestrial gravitational action (great molecular cohesion).

A simplistic and at the same time conservative analogical mathematical model was chosen, which ignores the size of the saliva drops. The model is based on a set of projectiles (SARS-CoV-2) launched from above from the contaminating focus (nose, mouth) of an emitting entity into the fluid field of the atmospheric air.

Considering that SARS-CoV-2 moves in a two-dimensional vertical plane, the kinematics of motion is expressed by the group of Eq. (1).

$$\begin{aligned} x &= \lambda_x v_o t \\ y &= \frac{1}{2}\lambda_y g t^2 \\ y &= \left(\frac{\lambda_y g}{2\lambda_x^2 v_o^2}\right) x^2 \end{aligned} \tag{1}$$

Where: x, y, are the coordinates of coronaviruses originating in the emergent focus of the person contaminating (nose, mouth) by coughing or sneezing;v_o, is the velocity at the most critical position of reach (horizontal); λ_x,λ_y , are damping factors due to the field of shear stress caused by the kinematic viscosity of the air; g, is earth gravity; t, is time.

The maximum horizontal range of $S_{máx}$ the SARS-CoV-2 is given by Eq. (2).

$$S_{máx} = \left(\frac{\lambda_x^2}{\lambda_y g}\right) v_o^2 \tag{2}$$

The shear stress field of the atmospheric air in which the SARS-CoV-2 moves is expressed by the tensor vector of the group of Eq. (3).

$$\begin{aligned} \tau_{xy} &= \mu\left(\frac{\partial v_x}{\partial y} + \frac{\partial v_y}{\partial x}\right) \\ \tau_{xz} &= \mu\left(\frac{\partial v_x}{\partial z} + \frac{\partial v_z}{\partial x}\right) \\ \tau_{yz} &= \mu\left(\frac{\partial v_y}{\partial z} + \frac{\partial v_z}{\partial z}\right) \end{aligned} \tag{3}$$

Where: τ_{xy} ,τ_{xz}, τ_{yz} are the components of the shear stress tensor due to air viscosity; v_x, v_y, v_z, is the atmospheric air velocity field; is the μ dynamic viscosity of atmospheric air.

The Reynolds Number that describes the movement of SARS-CoV-2 in atmospheric air under normal conditions is given by Eq. (3).

$$R = \frac{v d_c}{\vartheta} \tag{4}$$

Where: R, is the Reynolds Number; v , is the v settling velocity of the SARS-CoV-2; d_c , is the diameter; ϑ, is the kinematic viscosity of the air under normal conditions.

3. Results and Discussion

3.1 Geometry of Movement

The trajectory followed by each SARS-CoV-2 particle, in a vertical plane, is a second-degree semi parabola with a concave downward branch and apex at the source of the contamination of the emitting entity (nose, mouth), according to the third equation of the group (1).

3.2 Damping of SARS-CoV-2 in the Viscous Medium

In accordance with the tensor field of atmospheric air due to the effect of air viscosity under normal conditions, it has been estimated that the damping factors affecting the movement of SARS-CoV-2 are:

$$\lambda_x = 0.50; \lambda_y = 0.02$$

It follows that, while in the horizontal movement the damping is only due to the effects of viscosity, in the vertical direction in addition to the viscous effects, the air buoyancy is influenced.

3.3 Maximum Horizontal Range of the SARS-CoV-2

The maximum horizontal distance varies with the initial speed of the SARS-CoV-2 output from the source of the contaminant (nose, mouth) at the most critical position (horizontal). For an estimated horizontal exit velocity between 0.80 and 1.2 m/s, ranges are estimated between 0.82 and 1.83 m, respectively (Eq. (2)).

3.4 SARS-CoV-2 Sedimentation Time

The sedimentation time until SARS-CoV-2 reaches the ground obviously depends on the height of the contaminating focus of the emitting entity (nose, mouth).

Considering an average height of 1.60 m from the contaminating source to the supporting floor, the estimated time to reach the floor is 4 seconds. Obviously, on interceptor surfaces located above ground level, SARS-CoV-2 will adhere in a much shorter time (second equation of group 1).

4. Conclusions

The two-dimensional trajectory of the coronavirus is a semi-parabola of second degree with a concave descending branch downwards and apex in the contaminating focus of the emitting entity (nose, mouth).

Under conditions of sustained virus transmission in the community that require strict physical separation measures, the minimum distance between people should be 1.80 m (6 feet) to avoid direct transmission. This is a conservative estimate with limitations on the exclusion of saliva drop size.

The coronavirus sedimentation time depends on the height of the contaminating focus of the emitting entity (nose, mouth), with respect to the floor, and is estimated to vary between 3 and 5 seconds. Clearly, on interceptor surfaces located above the floor the adherence time is much shorter.

During the fall or sedimentation of the coronavirus, any intersecting surface, before it reaches the ground, can become infected.

Due to its great weight, the coronavirus does not remain in the atmospheric air for long, precipitating later by the action of the earth's gravity, except in aerodynamic conditions in which it can remain suspended in the air for longer.

For the same location, the higher the temperature, the higher the viscosity of the air, the smaller the horizontal physical distance and the longer the settling time, and vice versa.

At a higher altitude above sea level (Peruvian highlands), under the same temperature conditions, the air viscosity increases, the horizontal physical distance decreases and the sedimentation time increases, and vice versa.

Conservatively, the minimum horizontal physical distance of 1.80 m (6 feet), between people, covers all the cases discussed above.

The results obtained from this study are not valid for aerodynamic conditions of high turbulence of the atmospheric air (turbulent air flows). The validity of the results is restricted to closed environments and/or open areas only if a calm air condition prevails.

5. Recommendations

Respect the minimum distance between people of 2 meters, in order to avoid direct infection.

Avoid contact with coronavirus-contaminated interceptor surfaces, otherwise hand washing with soap is indispensable.

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