Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1

TO THE EDITOR: A novel human coronavirus that is now named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (formerly called HCoV-19) emerged in Wuhan, China, in late 2019 and is now causing a pandemic. We analyzed the aerosol and surface stability of SARS-CoV-2 and compared it with SARS-CoV-1, the most closely related human coronavirus.

We evaluated the stability of SARS-CoV-2 and SARS-CoV-1 in aerosols and on various surfaces and estimated their decay rates using a Bayesian regression model (see the Methods section in the Supplementary Appendix, available with the full text of this letter at NEJM.org). SARS-CoV-2 nCoV-WA1-2020 (MN985325.1) and SARS-CoV-1 Tor2 (AY274119.3) were the strains used. Aerosols (<5 μm) containing SARS-CoV-2 (10^5.25 50% tissue-culture infectious dose [TCID50] per milliliter) or SARS-CoV-1 (10^6.75-7.00 TCID50 per milliliter) were generated with the use of a three-jet Collison nebulizer and fed into a Goldberg drum to create an aerosolized environment. The inoculum resulted in cycle-threshold values between 20 and 22, similar to those observed in samples obtained from the upper and lower respiratory tract in humans.

Our data consisted of 10 experimental conditions involving two viruses (SARS-CoV-2 and SARS-CoV-1) in five environmental conditions (aerosols, plastic, stainless steel, copper, and cardboard). All experimental measurements are reported as means across three replicates.

SARS-CoV-2 remained viable in aerosols throughout the duration of our experiment (3 hours), with a reduction in infectious titer from 10^3.5 to 10^2.7 TCID50 per liter of air. This reduction was similar to that observed with SARS-CoV-1, from 10^4.3 to 10^3.5 TCID50 per milliliter (Fig. 1A).

SARS-CoV-2 was more stable on plastic and stainless steel than on copper and cardboard, and viable virus was detected up to 72 hours after application to these surfaces (Fig. 1A), although the virus titer was greatly reduced (from 10^3.7 to 10^0.68 TCID50 per milliliter of medium after 72 hours on plastic and from 10^3.7 to 10^0.68 TCID50 per milliliter after 48 hours on stainless steel). The stability kinetics of SARS-CoV-1 were similar (from 10^1.4 to 10^0.7 TCID50 per milliliter after 72 hours on plastic and from 10^1.6 to 10^0.6 TCID50 per milliliter after 48 hours on stainless steel). On copper, no viable SARS-CoV-2 was measured after 4 hours and no viable SARS-CoV-1 was measured after 8 hours. On cardboard, no viable SARS-CoV-2 was measured after 24 hours and no viable SARS-CoV-1 was measured after 8 hours (Fig. 1A).

Both viruses had an exponential decay in virus titer across all experimental conditions, as indicated by a linear decrease in the log_{10}TCID50 per liter of air or milliliter of medium over time (Fig. 1B). The half-lives of SARS-CoV-2 and SARS-CoV-1 were similar (from 10^3.4 to 10^0.7 TCID50 per milliliter after 72 hours on plastic and from 10^3.6 to 10^0.6 TCID50 per milliliter after 48 hours on stainless steel). On copper, no viable SARS-CoV-2 was measured after 4 hours and no viable SARS-CoV-1 was measured after 8 hours. On cardboard, no viable SARS-CoV-2 was measured after 24 hours and no viable SARS-CoV-1 was measured after 8 hours (Fig. 1A).

We found that the stability of SARS-CoV-2 was similar to that of SARS-CoV-1 under the experimental circumstances tested. This indicates that differences in the epidemiologic characteristics of these viruses probably arise from other factors, including high viral loads in the upper respiratory tract.
Aerosols Copper Cardboard Stainless/Steel Plastic

Titer (TCID50/liter of air)

10^4 10^2 10^3 10^1 10^0

Hours

0 0.5 1.0 2.0 3.0

A Titer of Viable Virus

SARS-CoV-2 SARS-CoV-1

B Predicted Decay of Virus Titer

SARS-CoV-2 SARS-CoV-1

C Half-Life of Viable Virus Aerosols

SARS-CoV-2 SARS-CoV-1

SARS-CoV-2 SARS-CoV-1

SARS-CoV-2 SARS-CoV-1

SARS-CoV-2 SARS-CoV-1

SARS-CoV-2 SARS-CoV-1

SARS-CoV-2 SARS-CoV-1
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