The total number and mass of SARS-CoV-2 virions

Ron Sender[1†], Yinon M. Bar-On[1†], Shmuel Gleizer[1], Biana Bernsthein[1,2], Avi Flamholz[3], Rob Phillips[3,4], Ron Milo[1]

[1]Weizmann Institute of Science, Rehovot 7610001, Israel
[2]Present address: Ragon Institute of MGH, MIT and Harvard, Cambridge, MA 02138, USA
[3]California Institute of Technology, Pasadena, CA 91125, USA
[4]Chan Zuckerberg Biohub, 499 Illinois Street, SF CA 94158, USA

† Equal contribution
*Ron Milo is the corresponding author name here
Email: ron.milo@weizmann.ac.il

Abstract:

Quantitatively describing the time course of the SARS-CoV-2 infection within an infected individual is important for understanding the current global pandemic and possible ways to combat it. Here we integrate the best current knowledge about the typical viral load of SARS-CoV-2 in bodily fluids and host tissues to estimate the total number and mass of SARS-CoV-2 virions in an infected person. We estimate that each infected person carries 10^9-10^{11} virions during peak infection, with a total mass in the range of 1-100 µg, which curiously implies that all SARS-CoV-2 virions currently circulating within human hosts have a collective mass of only 0.1-10 kg. We combine our estimates with the available literature on host immune response and viral mutation rates to demonstrate how antibodies markedly outnumber the spike proteins and the genetic diversity of virions in an infected host covers all possible single nucleotide substitutions.

Significance:

Knowing the absolute numbers of virions in an infection promotes better understanding of the disease dynamics and the response of the immune system. Here we use the best current knowledge on the concentrations of virions in infected individuals to estimate the total number and mass of SARS-CoV-2 virions in an infected person. Although each infected person carries an estimated 1-100 billion virions during peak infection, their total mass is no more than 0.1 mg. This curiously implies that all SARS-CoV-2 virions currently in all human hosts have a mass of between 100 gram and 10 kilogram. Combining the known mutation rate and our estimate of the number of infectious virions we quantify the formation rate of genetic variants.