Learning from the COVID-19 pandemic: Concepts for good decision-making

Aprendiendo de la pandemia COVID-19: Conceptos para una buena toma de decisiones

To the Editor:

1) Recognizing the enemy

COVID-19 is caused by the SARS-CoV-2 virus, which due to its phylogenetic relationships shows a clear relationship with SARS-CoV-1 (SARS agent) and therefore with a very probable origin in bat reservoir (Macrochiroptera)\(^1\). Bats have more than 76 viruses with human pathogenic potential, such as Rabia, Marburg, Hendra, Nipah, Menangle, Tioman, Ebola, and the SARS and MERS coronaviruses\(^2,3\). Therefore this is probably an emerging zoonosis as a consequence of the transgression of the specific barrier, a phenomenon known as spillover.

After advanced studies on the subject, a case fatality of 1.38% (95% CrI: 1.23-1.53\%)\(^5\) has been determined, which is not so high compared to other diseases. Although it has caused a large number of deaths, it is not comparable to the number of deaths that TBC or
others. For example, COVID-19 reports 175,694 deaths today in 3 months, seasonal influenza 290,000-650,000 in one year, HIV 570,000-1,100,000, Malaria 450,000, TBC 1,300,000-1,500,000 a year.

So what is the problem? The problem is the large number of cases in a short period of time, that is, what we call an epidemic (a pandemic if it involves the entire world). This produces saturation of health systems and increases case fatality due to lack of adequate treatment, reaching values up to 7.7% as the tragic Italian example. This is potentiated by the saturation of the health system with other respiratory diseases (seasonal influenza, SRV, adenovirus, etc.) and produces a “domino effect” on other serious diseases that need intensive treatment units (ICU).

The consequence of this is that the enemy is not the SARS CoV-2 virus. It is the accelerated transmission of this: the COVID-19 epidemic.

2) Estimating the transmission capacity of the virus.

The natural transmission capacity of the virus can be estimated through the basic reproductive number \( R_0 \) of COVID-19: the number of new cases produced on average by each case in a serial interval, in a completely population susceptible. The serial interval \( \tau \) corresponds to the average time that passes between contagion and contagion. It is equivalent to the population concept of generational time. For example, the human life expectancy is about 80 years and their generation time is 30 years, in the same way for the infective contact generation time is \( \tau = 5 \) days). Although there is controversy in this regard\(^{11,12} \), an approximate and reasonable value for COVID-19 is \( R_0 = 2.35 \).

However, during an epidemic, the size of susceptible population decreases, and as a consequence, the probability of transmission decreases until at some point the effect known as herd immunity occurs. That is the transmission slows down and finally stops. This generally occurs at a prevalence level \( p = 1-1 / R_\gamma \) which in the case of COVID-19 is approximately 60%\(^{12} \) (57.4% for \( R_\gamma = 2.35 \)). When epidemiological and disease control measures are taken, \( R_0 \) is not the best measure of transmission during the epidemic. A better parameter is the effective reproductive number \( Re(t) \), which corresponds to the same concept as \( R_\gamma \) but under the effects of control and mitigation interventions during the epidemic, and can be expressed as \( Re(t) = q(t)R_\gamma \), where \( q(t) \) represents the proportion of susceptible over time\(^{13} \).

Therefore, it is clear that if the problem is the transmission and the overload of the health system, it is necessary to decrease \( Re(t) \).

3) Estimating the burden of the health system

Since the most severe cases need to be admitted to the ICU, it is adequate to measure the ICU and compare it with the ICU availability of the ICU.

Let us look at two ways:

a) Maximum daily tolerance of patients (MT): if we have an availability of \( X \) ICUs and each ICU is used on average 14 days\(^5,7 \) then the system will only tolerate \( X / 14 \) patients per day. Since 5% of patients require an ICU, the system has a maximum daily tolerance of \( MT = (X / 14) / 0.05 = 20 (X / 14) \) patients each day. Example: if we have 500 ICUs, 36 daily admissions will be tolerated or equivalently 714 new cases/day.

b) Expected ICU burden (\( E(\text{ICU}) \)): The number of new patients occurring in a serial interval (5 days) can be calculated by multiplying the number of “active” infected people \( (I(t)) \) by \( Re(t) \). The active infected people can be estimated as the new cases accumulated in the last 2 weeks (14 days). Thus, the new cases generated in a serial interval \( (C(t + \tau)) \) will be \( C(t + \tau) = Re(t)I(t) \). Since 5% of them will need an ICU with a delay of one week\(^5,6 \), it can be estimated that \( E(\text{ICU}) = 0.05C(t + \tau) \) in approximately two weeks. This value can then be compared with the number of ICUs available. Example: if there are 5,000 active infected people and \( Re(t) = 1.1 \), 5,500 cases will be generated in 5 days and we will need 275 ICUs available in 2 weeks.

4) Decreasing \( Re(t) \) with epidemiological interventions

Since \( Re(t) = q(t)R_\gamma \) and \( q(t) \) represents the proportion of susceptible population over time and decreases throughout the epidemic, there will be a natural reduction in \( Re(t) \) due to herd immunity. However, unless a vaccine is created this takes a long time and would necessarily result in a large number of deaths and a saturation of health systems. Then we must decrease \( R_\gamma \).

The reproductive number can be expressed as:

\[
R_\gamma = \frac{\beta X_0}{(\gamma + \mu)},
\]

where \( \beta \) is the transmission coefficient, \( X_0 \) is the initial density of susceptibles, \( \gamma \) is the recovery rate and \( \mu \) the mortality rate. That is, \( R_\gamma \) is the product of the reproductive potential \( (\beta X_0) \) and the infective life expectancy \( (1 / (\gamma + \mu)) \). A first idea then is to increase \( \gamma \), finding a treatment, which until now has not been possible. Since we cannot modify \( X_0 \), we have to decrease the transmissibility coefficient.

The transmission coefficient can be expressed as:

\[
\beta = bP(I/C)P(C),
\]

where \( b \) is the contact rate between people, \( P(C) \), the probability of infectious contact and \( P(I/C) \) is the probability that this infectious contact yields an infection\(^{15,16} \). It follows, that epidemiological interventions must be aimed at reducing one or more of these three factors:
a) **Probability de un contacto infeccioso resultante en una infección** \( P(I/C) \): medidas de higiene personal, uso de desinfectantes como gel-alcohol, lavado de manos, uso de mascarillas.

b) **Contact rate \( b \)**: medidas de inmovilidad y distanciamiento social.

c) **Probabilidad de contacto infeccioso** \( P(C) \): traceabilidad e identificación de infectados e contáctos, cierre de escuelas y universidades, cuarentenas, cordon sanitario y aislamiento.

Estas intervenciones han sido efectivas en reducir el inicial \( R_0 = 2.38 \) a valores \( Re(t) \) de 1.1 (cálculos personales) en Chile. Sin embargo, se debe señalar que a pesar de no existir un vacuna (que afecta directamente \( P(I/C) \)) y \( q(t) \), el virus retiene la capacidad de volver a valores cercanos a \( R_0 \) cuando las intervenciones epidemiológicas son relajadas, ya que la inmunidad no ha sido alcanzada. La escalarmiento de las intervenciones debe considerar, al menos, cuatro aspectos: carga de actividad infecciosa \( I(t) \), número reproductivo efectivo \( Re(t) \), carga del sistema de salud y eficacia diagnóstica, que es lo que permite identificar casos, su traceabilidad e identificación. La escalarmiento de las intervenciones será más riesgoso y la carga en el sistema de salud más alta si se aumenta la carga activa infecciosa y se reduce el número efectivo reproductivo y la carga en el sistema de salud. La escalarmiento será menor y la carga en el sistema de salud más baja con una mayor carga activa infecciosa y un número efectivo reproductivo más bajo.

**Mauricio Canals Lambarri**

Programa de Salud Ambiental, Escuela de Salud Pública, Facultad de Medicina, Universidad de Chile. Santiago, Chile.

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**References**


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**Address author:**

Dr. Mauricio Canals
Programa de Salud Ambiental, Escuela de Salud Pública y Departamento de Medicina, Facultad de Medicina, Universidad de Chile. Independencia 939, Santiago, Zip code 8380453, Chile. mcanals@uchile.cl.