Short Communication

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2021.39.006269

From Pandemic to Apocalypse

Roumen Tsekov*

Department of Physical Chemistry, University of Sofia, 1164 Sofia, Bulgaria

***Corresponding author:** Roumen Tsekov, Department of Physical Chemistry, University of Sofia, 1164 Sofia, Bulgaria

ARTICLE INFO

Received: September 24, 2021

Published: October 04, 2021

ABSTRACT

Citation: Roumen Tsekov. From Pandemic to Apocalypse. Biomed J Sci & Tech Res 39(2)-2021. BJSTR. MS.ID.006269.

Introduction

The current study is an urgent warning on the Earth Day 2020 to prevent the blast of the COVID-19 pandemic to apocalypse. It is shown that the pandemic equations become unstable at reproduction numbers above 3.5, which could reflect in a chaotic catastrophe. There are many complex models describing pandemic kinetics [1,2]. In the current study we propose as chemists a minimalistic model based on chemical kinetics. Such type of equations describes different phenomena due to the universality of non-equilibrium thermodynamics developed by Onsager [3]. If $X(t)$ is the fraction of infected people, its temporal dynamics will obey, the following nonlinear evolutionary equation

$$dX/dt = \varpi X(1-X) - X/\tau \quad (1)$$

The first term on the right-hand side describes transfer of coronavirus from infected to healthy people with a characteristic frequency ϖ. Obviously, it corresponds to a second-order chemical reaction, since there are two different sets of people. Meetings among healthy or infected people do not affect the infection rate. The other relaxational term in Eq. (1) is due to either recovery or death of infected people and τ is the mean lifetime of infection. The favorite solution of Eq. (1) is $X_1 = 0$ but there is another stationary solution $X_2 = 1 - 1/R$, which could be high at large reproduction number $R = \varpi\tau$. The deterministic logistic function is the solution of Eq. (1), which tends at large time to the healthy X_1 if $R \le 1$ or the pandemic X_2 if $R \ge 1$. The maximal infection rate appears in the meddle at $X_2/2$. One can recognize in Eq. (1) the well-known SIS model from epidemiology.

A peculiarity of the nonlinear Eq. (1) is the chaotic behavior. Introducing the dimensionless time $T = t/\tau$, being the natural scale of the infection evolution, Eq. (1) can be rewritten as

$$dX/dt = RX(1-X) - X \quad (2)$$

The discreetness of the society requires $dX/dT = X_{k+1} - X_k$ to be expressed by a finite difference and in this case Eq. (2) reduces straightforward to the standard logistic map [4,5]

$$X_{k+1} = RX_k(1-X_k) \quad (3)$$

The bifurcation diagram of the map (3) shows at Figure 1 that the pandemic solution X_2 is unique in the range $1 \le R \le 3$.

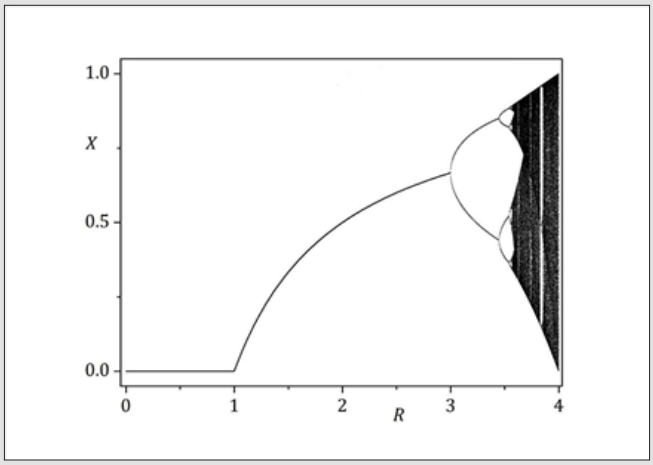

Figure 1: The stationary fraction of infected people as a function of the reproduction number.

At larger reproduction number $R > 3$ a bifurcation hierarchy takes place [6]. Any bifurcation indicates oscillations between healthy-rich and infected-rich states, and this could trigger social segregation and confrontation. The onset of deterministic chaos at $R > 3.5$ marks the beginning of a cascade of chaotic apocalypses

with unpredictable stochastic behavior. An unforeseen salvation is, however, that according to Figure 1 commensurable probabilities hold for the End ($X=1$) and a new Beginning ($X=0$) at $R=4$. Though Einstein did not believe that God plays dice with the Universe, this would be the case here, because the logistic map has no solution at $R>4$.

Conclusion

The present study aims either educational or scientific goals. The used standard mathematical apparatus is well known in the classical theory of the chaotic systems and the paper is a useful demonstration how it could be applied to important living systems as well. The main contribution to science is the application to epidemiology. The traditional pandemic studies try to solve complex systems of nonlinear differential equations. Outstanding scientists have developed sophisticated models for precise predictions of pandemic but they never considered the bifurcation dynamics of their models. Indeed, the described SIS model is too simple to forecast the exact evolution of the COVID pandemic but we just wanted to stress that any epidemic model is non- linear, due to the infection spreading step, and this can result in a chaotic behavior. In conclusion, to fight effectively with the coronavirus epidemy people should try to reduce the reproduction number $R=\varpi\tau$ either by suppressing ϖ via social distancing, masks and immunization, for instance, or by decreasing τ via advanced medical care. In any case R should be capped below 3.5 to prevent chaotic disasters. Of course, the present minimalistic model is oversimplified and its numerical predictions could be far from the reality. However, the exact models are even more nonlinear, which presumes a more complex chaotic behavior. But the World knew already that an apocalyptic pandemic was coming [7].

Acknowledgment

The author is thankful to Dr. V. Tonchev for inspiring discussions and grateful to Dr. A. Fauci and Dr. R.W. Eisinger for encouragement. Baron May of Oxford passed away at the day of the first publication of the paper online, R.I.P. Robert M. May [4].

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ISSN: 2574-1241

DOI: 10.26717/BJSTR.2021.39.006269

Roumen Tsekov. Biomed J Sci & Tech Res

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