



Method to evolution's model of the epidemic of the Covid-19. A case's illustration

Método del modelo evolutivo de la epidemia de Covid-19. Ilustración de un caso

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ABSTRACT

Introduction: At present they yield different mathematical models to describe the evolution of the epidemic of the Coronavirus, however the realized predictions do not characterize themselves for the desired precisions, and at times, they had been applied models of continuous, probabilistic processes, still when we know that they have an operation with data, which represent a discontinuous phenomenon of behavior (of finite leaps), aspect that affects the approximations of the real development of the epidemic of the new Coronavirus. Aims to: they develop a mathematical algorithm for the prediction of the epidemic of the Covid-19 through mathematical quantitative and qualitative models in compliance with humanity's needs according to the evolution of the paradigms. Methods: Theoretical methods are used: analysis and synthesis, induction and deduction, abstraction and concretion, and the logical historical method. Revision of reports of studies. Construction of function curves and their reasons for change. Mathematical methods, procedures and algorithms are applied, as well as the focuses of the clinical and epidemiologic methods. Results: The empirical methods applied are framed mainly in the observation of the records of the experimental data, the bibliographic review, in order to deepen the problem and obtain information on the main difficulties that affect the research process, and the published reports, from of the search for methods and procedures. The document review method is used, through books, and articles referring to the topic epimics evolution about experimental and statistics data in the Scielo, DOAJ, Latindex, Google Scholar Databases, Elsevier, among others. A method of work is designed, which makes easy the analysis of the quantitative real registered data to characterize the evolution of the epidemics. The May 6, 2021 is illustrated by means of the yielded information in Israel, as from the December 14, 2020. Conclusions: An alternative constitutes the mathematical designed algorithm that it assures the tracking and the control of the epidemics, as well as the performance of the data recollected to understand, explaining and interpreting essential features, from the topologic point of view, which represent the global tendencies of growth, decrease, and the cycle of epidemic attenuation.

Keywords: method, epidemics, quantitative and qualitative mathematical models, prediction, covid-19.

RESUMEN

Introducción: Actualmente se utilizan diferentes modelos matemáticos para describir la evolución de la epidemia del Coronavirus; sin embargo, las predicciones obtenidas no alcanzan la precisión deseada. En ocasiones, se han aplicado modelos de procesos probabilísticos continuos, aun sabiendo que operan con datos que representan un fenómeno de comportamiento discontinuo (de saltos finitos), aspecto que afecta las aproximaciones al desarrollo real de la epidemia del nuevo Coronavirus. Objetivos: Desarrollar un algoritmo matemático para la predicción de la epidemia de Covid-19 mediante modelos matemáticos cuantitativos y cualitativos que respondan a las necesidades de la humanidad según la evolución de los paradigmas. Métodos: Se emplean métodos teóricos: análisis y síntesis, inducción y deducción, abstracción y concreción, y el método lógico-histórico. Revisión de informes de estudios. Construcción de curvas de función y sus razones de cambio. Se aplican métodos, procedimientos y algoritmos matemáticos, así como los enfoques de los métodos clínicos y epidemiológicos. Resultados: Los métodos empíricos aplicados se enmarcan principalmente en la observación de los registros de datos experimentales, la revisión bibliográfica, con el fin de profundizar en el problema y obtener información sobre las principales dificultades que afectan el proceso de investigación, y los informes publicados, a partir de la búsqueda de métodos y procedimientos. Se utiliza el método de revisión documental, a través de libros y artículos que hacen referencia al tema de la evolución epidémica sobre datos experimentales y estadísticos en las bases de datos Scielo, DOAJ, Latindex, Google Scholar, Elsevier, entre otras. Se diseña un método de trabajo que facilita el análisis de los datos cuantitativos reales registrados para caracterizar la evolución de las epidemias. El 6 de mayo de 2021 se ilustra mediante la información obtenida en Israel, a partir del 14 de diciembre de 2020. Conclusiones: Una alternativa es el algoritmo matemático diseñado, que garantiza el seguimiento y el control de las epidemias, así como el análisis de los datos recopilados para comprender, explicar e interpretar características esenciales, desde el punto de vista topológico, que representan las tendencias globales de crecimiento, disminución y el ciclo de atenuación de la epidemia.

Palabras clave: método, epidemias, modelos matemáticos cuantitativos y cualitativos, predicción, covid-19.

INTRODUCTION

At present they yield different mathematical models to describe the evolution of the epidemic of the Coronavirus, however the realized predictions do not characterize themselves for the desired precisions, and at times, they had been applied models of continuous, probabilistic processes, still when we know that they have an operation with data, which represent a discontinuous phenomenon of behavior (of finite leaps), aspect that affects the approximations of the real development of the epidemic of the Covid-19.(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20)

Disease transmission is represented through mathematical models defined by differential equations.(8, 13,15,17, 18, 19, 20, 21, 22, 23, 24, 25, 26)Thus, linear and non-linear correlation models have been widely referenced by different authors, who have applied them in various fields of knowledge. For example,(27, 28, 29, 30,31, 32, 33, 34, 35, 36)make use of non-linear models such as of the Brody, Von Bertalanffy, Richards, logistic and Gompertz models, called fixed effects models.

Thus, other authors propose and analyze six types of logistic and growth models to approximate the data on the distribution of COVID-19, while proposing a clear answer to the possible advantages of some considerations. They investigate intrinsic properties of growth models with transfer of polynomial variables, which provide an accurate approximation of the specific data on the pandemic.

These models are used in the treatment of questions in different fields of scientific knowledge, based on numerical data in a mathematical model to calculate the cases.(34, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50)However, the results published in consideration of the author do not specify, and predict the results as expected at the present time to control the evolution of the epidemic, subject to measures that minimize growth, which is observed in almost all recent publications, without actually representing the speed of spread of the epidemic, as an essential element in their development.

In countries such as Cuba, the rate of change in the percentages of daily illnesses from Covid-19 with respect to time is exceeded (speed of spread of the epidemic), so that in the months of July and August 2021 there have been registered percentages of patients by the Covid-19 records, facts that move the country.

It is defined as a scientific problem: how do we develop a mathematical algorithm for the prediction of the epidemic of the Covid-19 through mathematical quantitative and qualitative models in compliance with humanity's needs? It aims to: they develop mathematical algorithm for the prediction of the epidemic of the Covid-19 through mathematical quantitative and qualitative models in compliance with humanity's needs according to the evolution of the paradigms.

MATERIALS AND METHODS

Theoretical methods are used: analysis and synthesis, induction and deduction, abstraction and concretion, and the logical historical method. Construction of function curves and their reasons for change. Mathematical methods, procedures and algorithms are applied, as well as the focuses of the clinical and epidemiologic methods.

A methodology is designed to ensure the processes of understanding, explanation and interpretation in the analysis of experimental data, to guarantee the reliability and veracity of the study.

The empirical methods applied are framed mainly in the observation of the records of the experimental data, the bibliographic review, in order to deepen the problem and obtain information on the main difficulties that affect the research process, and the published reports, from of the search for methods and procedures.

The document review method is used, through books, and articles referring to the topic epidemics evolution about experimental and statistics data in the Scielo, DOAJ, Latindex, Google Scholar Databases, Elsevier, among others.(51)

RESULTS

The origin of the design of the work method proposed by the author of this article arises from his doctoral thesis, as well as reports of publications before, and after the final report of this study was concluded in June 2019. In this way, an algorithm is proposed mathematical associated with the evolution of epidemics. A computer program (Excel) is used that facilitates the calculations and graphs the information collected:

Step 1. The daily information of the patients diagnosed with the disease (Covid-19) is collected

in the first column.

Step 2. The percentage with respect to the total mean population of the area or geographic zone is calculated in the second column.

Step 3. The percentage of patients accumulated daily is calculated, medical discharges and daily deaths are subtracted from the third column.

Step 4. The daily rate of change of the percentage of diagnosed patients is calculated, as the difference of two consecutive percentages, divided by the minimum unit of time; constitutes an approximation to the speed of propagation of the epidemic, in the fourth column.

Step 5. The daily rate of change of the accumulated patients is calculated by the difference of the consecutive percentages (numerator) and divided by the minimum unit of time; constitutes an approximation to the speed of spread of the epidemic, in the fifth column.

Step 6. The graphs of the percentage of daily patients, and the percentage of accumulated patients, and their corresponding rates of change, are constructed from the data in the columns corresponding to the second, third, fourth, and fifth columns.

Step 7. The intervals of increasing and decreasing trend of the percentages are indicated; that is to say, the global trends of the percentage of patients (accumulated), and of the rate of change of the corresponding percentage of patients.

Step 8. The global trends of the evolution of the epidemic in general are deduced.

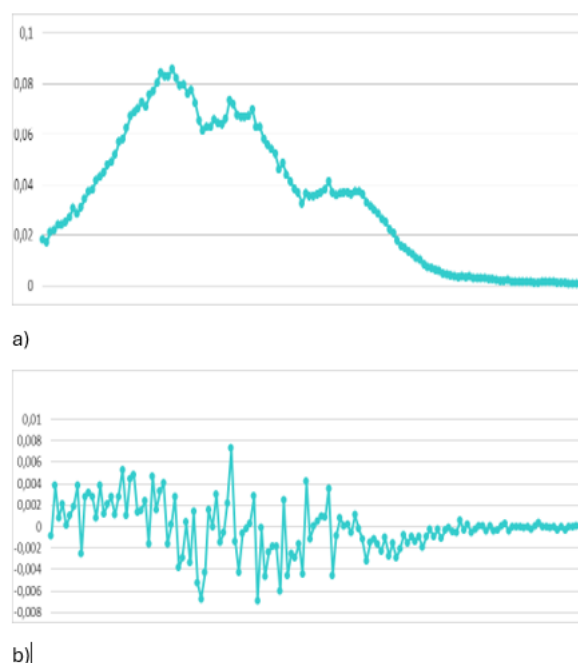
Step 9. Changes in the evolution of the epidemic are predicted, as well as its possible causes, effects, controlled and uncontrolled effective measures.

The mathematical algorithm designed to detail the evolution of the Covid-19 epidemic in Israel is applied, from December 14, 2020 to May 6, 2021; according to the information collected, through real data extracted from the Internet.(51)

DISCUSSION

The following illustrates the monitoring of the evolution of the Covid-19 epidemic in Israel, from December 14, 2020 to May 6, 2021.

Figure 1. Polygonal line of daily percentages of sick persons for Covid-19 (y axis) and the time measured in days (horizontal axle) and the polygonal line of the reason of change daily permanent percentages for sick persons for Covid-19 (y axis) and the time measured in days (horizontal axle).



A mathematical model that describes the population evolution happening very different health situations by nature is examined. Which may apply him with respect to Coronavirus' evolution (Covid-19).

Changes are observed in the daily percentages, and in the rates of change of the daily per-

centages in polygonal A, and B respectively in figure 1, however it is necessary to identify the global trends of increasing and decreasing monotony; a relative maximum is reached, this first interval with an increasing global trend, corresponding to it the ratios of positive changes, different from zero.

Then a second interval with a decreasing global trend with negative rates of change, different from zero.

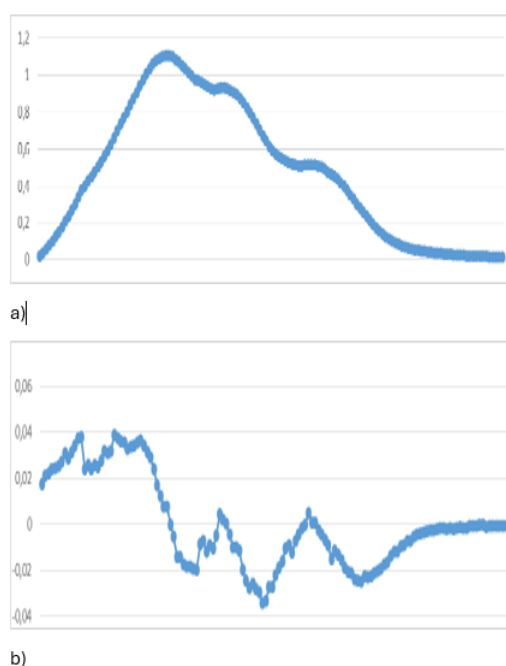
These cycles can be repeated several times. Until the general trend of the rate of change of the daily percentages is negative and positive, but decreases; and finally, for long periods of time, an approach to zero begins due to positive values, and negative values suddenly, which indicates the decrease in the percentages of daily patients, verified in polygonal A of figure 1, or vice versa, it is defined as an attenuation cycle epidemic.

As the behavior of the percentages of daily patients, and their rates of change are close (approximate) to zero, it is concluded that the control measures applied to reduce the epidemic in Israel until May 2021 are effective, otherwise it is necessary to continue the recording of daily information, reaffirming measures, for example in the case of Cuba.(52)

As a result of applying the elaborated algorithm, the following graphs are obtained, represented in figure 2: Traverse A and B.

The accumulated data are added during 14 consecutive days, there are no contradictions between the daily percentages in figure 1, and the accumulated percentages in figure 2.

Figure 2. Polygonal line of daily percentages of sick persons for Covid-19 (y axis) and the time measured in days (horizontal axle) and the polygonal line of the reason of change daily permanent percentages for sick persons for Covid-19 (y axis) and the time measured in days (horizontal axle).



The results of the real collected data represented are verified to clarify, specify, and demonstrate the global trends associated with the behavior of the evolution of the Covid-19 epidemic in Israel in the months of December 2020 to May 2021.

Changes are observed in the percentages of accumulated daily patients, and in the rates of change in the daily percentages corresponding to polygonal A, and B respectively in Figure 2, however it is necessary to identify the global increasing and decreasing trends; a relative maximum is reached, this first interval with an increasing trend, corresponding to the ratios of positive changes, different from zero.

A second interval with a decreasing global trend with negative rates of change, different from zero.

These cycles can be repeated several times. Until the general trend of the rate of change of the daily percentages is negative and positive; decreases for prolonged times, begins to approach zero due to positive and negative values, suddenly, which indicates the decrease in the percentages of daily patients, verified in polygonal A of figure 2, or vice versa, the attenuation cycle is identified

epidemic. After an uncontrollable sprout, again in this month of August 2021, the global increasing tendency in Israel is identified, which indicates that the vigilance of the evolution of the epidemic has to be for ever.

As the behavior of the accumulated daily sickness percentages, and their corresponding change ratios are close (approximate) to zero, it is concluded that the control measures applied to reduce the epidemic in Israel until May 2021 are effective, otherwise it is necessary to continue recording daily information, reaffirm measures, and include others.

When comparing the graphs associated with the behavior of the epidemic, a topological equivalence is verified in figures 1 and 2.

For example, in the case of Cuba, publications are reported.⁽⁵²⁾ In figure 6, in which it is deduced that the epidemic at 100 days is reduced, according to the theoretical (quadratic) curves of the model used; however this prediction was not correct.

There is no correspondence by comparison between the polygonal lines of figures 1 and 2, which are obtained from the application of the algorithm proposed in this work, and the curves recently reported by different mathematical models to represent the evolution of the epidemic,^(53, 54) from the following aspects: clarity, precision, and prediction,

In the case of mathematical models applied in Colombia,⁽⁵³⁾ the data is interpreted on the basis of the first cycle of increasing global trend. Figure 1 of this article presents a point cloud of the accumulated data model. from day one to day 44, that is, the evolution of the epidemic, has not yet lasted in time, and practice has determined much longer and more diverse cycles, in the case of the Covid-19 epidemic.

It is concluded that the collected data have a quadratic behavior; However, it does not correspond to the reality of the epidemic evolution in Colombia, that is to say, if the data used in the research are random, the sample studied has the required size, thus for only pointing out aspects that influence the credibility of the results achieved in this study; however, it leaves aspects of considerable value, but too hasty.

In the report published by the authors of Plovdiv University,⁽⁵⁴⁾ which carries out a study analogous to the report developed in the research,⁽⁵²⁾ the first cycle of increasing global trend is identified in the model, starting at 51 days monitoring the evolution of the epidemic in Cuba from March to May 2020. It follows that the evolution of the epidemic in Cuba must be analyzed in longer periods of time, as it has actually happened.

It is recommended to compare the results of the application of the mathematical algorithm designed in this study report, which synthesizes the analysis, and the presentation of Figures 1 and 2 to characterize the evolution of the epidemic in Israel, compare with reports made by The author of this work, among others, according to the similarity of the graphs in their topological forms, when different biomedical phenomena of different nature are studied, and specifically the evolution of the dengue epidemic in Holguín.^(9, 11, 55, 56, 57, 58, 59) As well as the similarity and coincidence of the characteristics of the graphs of the elementary real functions of classical Mathematical Analysis, and the topological forms of the polygonal A and B of figures 1, and 2.

The transformation of the evolution of the Covid-19 epidemic is predictable in the coming months, from the complex current health situation in Cuba, according to the percentages of Covid-19 patients registered in August 2021, with evidence of a growing global trend, from the mass vaccination process, strict compliance, and aware of rectified control measures; as well as new measures.

CONCLUSIONS

They developed mathematical algorithm for the prediction of the epidemic of the Covid-19 through mathematical quantitative and qualitative models in compliance with humanity's needs according to the evolution of the paradigms.

An alternative constitutes the mathematical designed algorithm that it assures the tracking and the control of the epidemics, as well as the performance of the data recollected to understand, explaining and interpreting essential features, from the topologic point of view, which represent the global tendencies of growth, decrease, and the cycle of epidemic attenuation.

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CONFLICT OF INTEREST

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