

MODELING THE COVID-19 OMICRON VARIANT SPREAD IN ALGERIA WITH A PREDICTIVE SIR MODEL

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ABSTRACT:

On February 2020, Algeria declared the first infected case with the novel Coronavirus (SARS-CoV-2) announcing the country's involvement in the global COVID-19 crisis. Since then, infected cases have been continuously increasing, reaching 271 496 cases and 6881 related deaths on March 9, 2023. Therefore, it is important to study the trend of the disease to understand disease trends and to allow the adoption of the best preventive strategies. In this context, our study aims to use a predictive SIR model to understand the future epidemiology of COVID-19 in Algeria using data from January 1, 2022 to February 15, 2022. Results: Our results showed that the new epidemic peaked in Algeria will be after more than 8 months, with more than 54790 infected people and more than 1095 deaths. The reproduction number (R_0) was estimated at 1.0538.

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Conclusions: This model may possibly be useful for the National Health Authorities not only for the COVID-19 pandemic, but also for other diseases such as Influenza or Monkeypox. Thus, we recommend in priority initial vaccination, along with booster doses for all eligible individuals in order to control the spread of the disease.

Keywords: COVID-19, SIR model, Algeria, Omicron, Predictive epidemiology.

RESUME :

En février 2020, l'Algérie a enregistré son premier cas du nouveau Coronavirus (SARS-CoV-2), annonçant que le pays est désormais concerné par la COVID-19. Depuis, le nombre de personnes touchées n'a cessé d'augmenter, atteignant le 9 mars 2023 un total de 271 496 cas et 6881 décès liés à la maladie. Il devient donc nécessaire de suivre l'évolution de la maladie pour comprendre son évolution et permettre l'adoption des meilleures mesures de contrôle. Dans ce contexte, la présente étude vise à utiliser un modèle prédictif SIR pour comprendre l'épidémiologie future du COVID-19 en Algérie en utilisant les données du 1er janvier 2022 au 15 février 2022. Nos résultats ont montré que le nouveau pic épidémique en Algérie sera atteint après plus de 8 mois, avec plus de 54790 personnes infectées et plus de 1095 décès. Le nombre de reproduction (R_0) a été estimé à 1,0538.

Ce modèle peut être utile aux autorités sanitaires nationales pas uniquement pour la COVID-19, mais également pour d'autres applications comme pour que la grippe ou la variole du singe. Nous recommandons donc en priorité la vaccination et des doses de rappel pour toutes les personnes éligibles dans le but de freiner la transmission de la maladie.

Mots Clés: Total health expenditure; Determinants; VECM model; Econometric analysis; Algeria.

I. INTRODUCTION

The new Coronavirus disease (COVID-19) was first isolated in Wuhan, China, in 2019. Owing to its considerable effects and widespread, the World Health Organization (WHO) labeled it as a pandemic on March 2022 [1]. Considering its rapid growth in many countries and given the nonexistence of an effective medical solution [2], control measures were mainly based on non-pharmaceutical measures, including social distancing, quarantine and mask wearing [3].

Although the implementation of the above control measures, important variables, such as population density and the low number of vaccinated individuals, contributed to accelerating the spread of the disease [4].

In this pandemic context, Algeria has experienced enormous impairment. It is important to note that, according to statistics from November 2022, more than 600 million cases and more than 6 million related deaths were recorded worldwide. In Algeria, the number of cases caused by the COVID-19 was 271000 (6881 deaths) on November 07, 2022. Hence, it must be further considered that official cases in Algeria were only confirmed by PCR test [5].

Mathematical models have demonstrated their usefulness for estimating the spread of illness, recovery, fatality, and other important features. In fact, various recent research

articles have used a modeling approach to investigate both the different features and parameters of the epidemic and the efficiency of prevention measures.

Consequently, mathematical models can be considered effective and helpful tools for planning the best strategies to control the disease [6-7]. In this regard, the SIR model and its derivate such as SEIR model [8] have been used in many previous articles to simulate the virus propagation, also in Algeria [9]. The SIR model significance is represented in its capacity to produce a theoretical framework and forecasts that government officials can utilize to effectively control COVID-19 spread (in addition to other pandemics) in Algeria. Moreover, the effectiveness and importance of the model lie in its ability to adapt it to regions or countries. In addition, the specificity of the SIR model is that the more data are for a short period, the more stable the model will be.

The aim of this article is to define the parameters of a standard SIR model to analyze the COVID-19 severity over short and long-term periods, as well as to estimate the cumulative COVID-19 infection curve in Algeria. The characteristics of the model were estimated and the basic reproduction number R_0 was calculated.

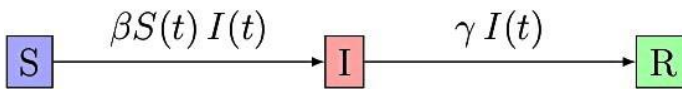
II. METHODS AND MATERIALS

For the investigation, we used an anonymized COVID-19 datasets provided by the Algerian health ministry including data from January 1, 2022 to February 15, 2022. Data from the beginning of the year were specifically chosen to verify the suitability of the model for the actual data after few months and to build an efficient model that allows us to predict the epidemic.

Three differential equations are required to model in order to study the epidemic's dynamics:

- (S) Susceptible individuals: not ill, susceptible to illness.
- (I) Infected individuals: ill, capable of transmitting infection.
- (R) Recovered individuals: contracted the disease, are no longer capable of transmitting it (permanently immunized, isolated, or dead).

Figure 01: Schematic representation of the SIR model



Source: The authors

In some variations of the model, we can have (E): "exposed" means individuals exposed to the disease.

In general, the total size of the population is admitted to be constant, i.e., $N=S+I+R$. where β is the parameter that controls the transition between S and I, i.e., the contact rate or the infection rate and γ which is the parameter controlling the transition between I and R is the cure rate or the recovery rate. A closed population is considered, i.e., no birth or death occurs and the selected virus with no incubation period.

So, 3 differential equations are obtained:

$$\frac{dS(t)}{dt} = -\beta S(t)I(t) \dots \dots \dots (1)$$

We have a "-" sign because over time this group shrinks. Indeed, the epidemic has already affected a number of people. The value shall be proportional to the number of infected persons, individuals likely to be infected and β , which is the rate of infection, the probability rate of the virus transmission and the number of contacts between an infected subject and persons likely to be infected according to equation 2:

$$\frac{dI(t)}{dt} = -\beta S(t)I(t) - \gamma I(t) \dots \dots \dots (2)$$

Knowing that γ is a parameter of cure rate or recovery rate, this equation describes the increase in the value of infected over time. We add (the sum) of the previous number with the sign "+" to mean that the number of infected increases with time and the second negative term, which means that a number of infected becomes immune. Therefore, the rate of immunized patients is calculated by equation 3:

$$\frac{dR(t)}{dt} = \gamma I(t) \dots \dots \dots (3)$$

The second positive term represents the rise in the number of withdrawn patients, i.e., the rate of immunized patients. The epidemic requires a chain of transmission: infected people must infect susceptible people. The differential equations system is given by equation 4:

$$\left\{ \begin{array}{l} \frac{dS(t)}{dt} = -\beta S(t)I(t) \\ \frac{dI(t)}{dt} = \beta S(t)I(t) - \gamma I(t) \dots \dots \dots (4) \\ \frac{dR(t)}{dt} = \gamma I(t) \end{array} \right.$$

Through differential equations system in eq. 4, the parameter R_0 in the equation 5 defines the mean number of new infections caused by one infected individual

This value depends on R_0 coefficient, which is related to the recent observations of the epidemic, which means that experts in epidemiology do not rely only on this value to determine the acceptable level of vaccination, but also on the course of the epidemic and its spread as well.

If $R_0 < 1$, the epidemic will become extinct. The length of time this process takes is usually determined by the size of the parameter.

If $R_0 > 1$, the epidemic may persist or even spread to the entire population. Generally, higher values of R_0 are more serious for the spread of the epidemic.

In our model, When the rate at which a newly infected person spreads the disease remains at the same rate β over the typical infectious phase ($1/\gamma$). The reproduction rate can be calculated by equation 5:

$$R_0 = \frac{\beta}{\gamma} \dots \dots \dots (5)$$

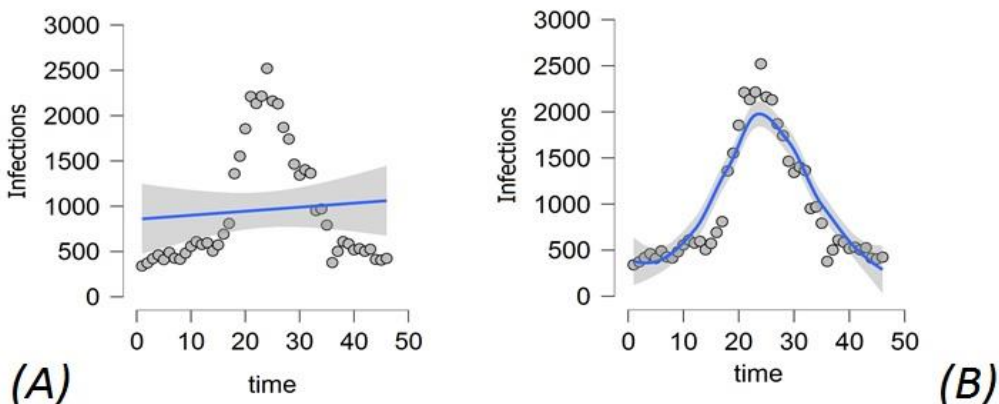
This study was designed as an analytical study using time series data from people infected with the Omicron variant in Algeria (from January 1, 2022 to February 15, 2022).

Here, we used a standard Susceptible–Infectious–Recovered model. The SIR model, divides N into three groups including Susceptible–Infected–Recovered individuals. It is important to specify that the first category represents the percentage related to the vulnerable community having a risk of being infected (those who have not been exposed to the disease). The second category is the percentage of the infected population (currently affected by the disease). The last category consists on the percentage of the recovering or relocating individuals (either recovered or dead individuals).

III. RESULTS AND DISCUSSION

According to Figure 2, it is clear that the trend in the logarithmic curve is almost absent. This means that the fourth wave was almost passed in Algeria on 15/02/2022.

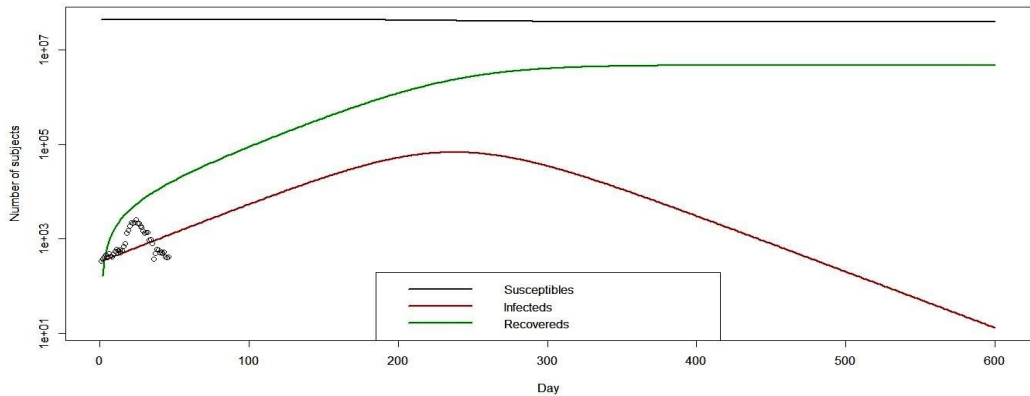
**Figure 02: (A) The number of confirmed COVID-19 cases in the country during the study period;
(B) Confirmed cases in Algeria (for the same period) on a logarithmic scale.**



Source: The authors using *R* Software.

In Algeria, on 15/02/2022; the reproduction number $R_0 \approx 1$, which means that one case is able to affect another; therefore, the virus is not spreading. Figure 3 shows An exponential increase in COVID-19 cases following this fourth wave represented by the predominance of the omicron variant, this result is logical when speaking of a pandemic. Moreover, also in Figure 3, the new epidemic peak in Algeria will be after more than 8 months, with more than 54000 infected and about 1095 related deaths, this is perfectly in line with the officially declared numbers. The parameter p represents the people immunized (equal to approximately 5% of the total population), which demonstrates the need for an intensive vaccination campaign. Figure 3 depicts the basic framework of the SIR model.

Figure 03 : Application of the SIR model for the number of cases in Algeria



Source: Drawn by the authors using data from [10].

Table 01: Statistics on the applied SIR model in Algeria

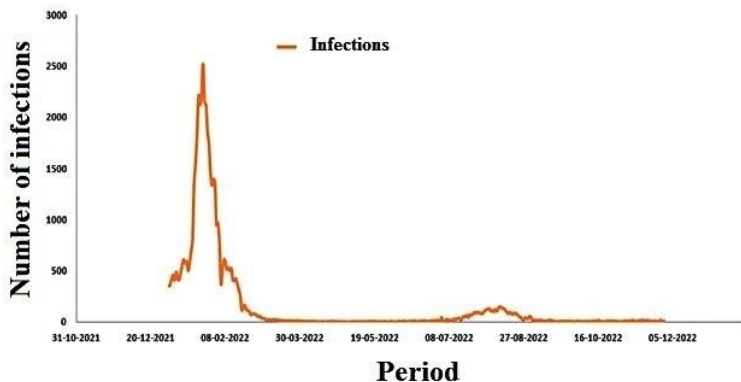
Country	R_0	P	Max (d)	Max (I)	HR (Height of Pandemic)	β	γ
Algeria	1.0538	0.05	1095.811	54790.57	243	0.5131	0.4868

Source: The authors

When the infection rate is $\beta = 0.513$ then a susceptible person will end up infected on average after $1/\beta = 2$ contacts, and when the recovery rate is $\gamma = 0.486$, then the person will be cured on average after of $1/\gamma = 2$ units of time (2 days). These results indicate the quick transmission of Omicron and its low degree of severity.

The SIR model applied in the present study can be exploited to predict infections and deaths numbers that will occur, and to estimate the timeframe during which the virus persists within a population. Additionally, it offers insights on reducing the virus’s impact, information that is almost impossible to infer solely from the recorded data.

Figure 04: The number of COVID-19 infections in Algeria (from 22-01-2020 to 30-11-2022).



Source: By the authors using data from [10]

Figure 4 shows COVID-19 infections in our country in the study period, it serves as a basis for comparison with the outcomes of the proposed SIR model. Both the trend and the number of infections align closely with our model's predictions. This study employed a classic SIR model to analyze the dynamics of COVID-19 spread in Algeria. Additionally, the number of deaths and the reproduction number were computed.

Generally, mathematical models in the field of epidemiology are conformed to reality. Nevertheless, the perfect model does not exist [11]. In addition, the majority of estimation models used since the start of COVID-19 were inefficient; this is why we used it during the end of the fourth wave (in the beginning of the year). After that, we waited until the end of the same year to analyze its efficiency. Although the calculation process that we made makes the parameter R_0 close to the value of 1, and this is because the wave has already ended, the entry of the epidemic in this stage does not mean its end, but makes the prediction a decisive stage. The estimated parameters of our SIR model were calculated using data of daily reported cases and deaths as declared by the Algerian health ministry. This model, which allows a long-term prediction, showed its usefulness.

Results showed that the reproduction number was nearly equal to 1. This value is lower than the reported number by Lounis et al. [9] ($R_0=1.2$) in the beginning of the pandemic in Algeria. Globally, this number has shown multiple variations in different countries as show by Purkayastha et al. [12].

The results showed also, that the new epidemic peak in Algeria would be after approximately 8 months, with more than 54790 infected and more than 1095 deaths

(Figure 3). The parameter p showed that vaccination must be continuous even at the end of the wave. Consequently, the number of vaccinated individuals will have to be considerably increased, in order to be better prepared for the next one. Therefore, the infection potential of COVID-19 in Algeria will decrease the next months to be very negligible, thus opening the prospect of a return to normality, which is encouraging for the population due to socio-economic damages of the pandemic in the country, as it is the case all over the world.

However, a point not to be overlooked, the parameters of the model were estimated using only affected individuals confirmed with RT-PCR, knowing the low number of performed tests that did not exceed 2500 tests / day (when the epidemic was in its most dangerous period), the number of actual cases could be far above the officially reported numbers. Additionally, some hospitals and health institutions no longer report cases. According to the authors' knowledge, the number of hospitalized individuals diagnosed with CT scan is higher than PCRs, which represents an important limitation of this study as well as the quality of data provided by the ministry.

Since the actual epidemiological data is now available for access, we compare, through Figure (4), the prediction results by the SIR model. What is interesting is that exactly 8 months after the peak of the fifth wave (01/24/2022), we found ourselves in front of the sixth wave, exactly as presented within this model. The findings indicate the process's extreme accuracy. Many studies of the SIR model have noted the epidemic's broad scope and ongoing nature, such as the study by Nesteruk [13]. Our study also agrees with results obtained by Ranjan [14] in India or Carolina Ribeiro and al. [15] in Brazil, Germany, and South Africa about the rapid spread of the Omicron variant and its low severity.

IV. CONCLUSIONS

In conclusion, an SIR model was applied using daily Health Ministry reports from Algeria to predict the Coronavirus epidemic evolution and to estimate the reproduction number. Our results showed a reproduction number nearly equal to 1. Additionally, the country will see an epidemic peak after 8 months and the balance will be 54000 infected individuals and about 1095 deaths.

This study showed that the classic SIR model could be applied to predict the pandemic also in Algeria, specifically after the appearance of Omicron variant. Additionally, it could be used in another region, or adapted to another pandemic, such as Influenza or Monkeypox. This model remains simple, basic, and practical and can provide some essential information for authorities, which can prevent the spread of the pandemics. Authorities should continue the vaccination campaign, even in a period where there is little

contamination, while focusing on booster doses to restore vaccine effectiveness and prolong immunity. These safety results could be helpful for the public health authorities in their fight against viruses in general and, in particular, future pandemics.

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