



## Investigation of spread of novel coronavirus (COVID-19) pandemic in MOROCCO & estimated confinement duration to overcome the danger phase

H. Bendaif<sup>1\*</sup>, B. Hammouti<sup>2</sup>, I. Stiane<sup>3</sup>, Y. Bendaif<sup>3</sup>, M.A. El Ouadi<sup>4</sup>, Y. El Ouadi<sup>2\*</sup>

1. Laboratory of Organic Chemistry, Macromolecular and Natural Products (LCOMPNURAC25), Faculty of Sciences, University of Mohammed First, Oujda, Morocco

2. Laboratory of Applied Analytical Chemistry, Materials and Environment (LCA2ME), Faculty of Sciences, University of Mohammed First, Oujda, Morocco

3. Department of Mathematics, Faculty of Sciences, University of Mohammed First, Oujda, Morocco

4. Engineer from the National School of Mines of Rabat-MOROCCO

\* Corresponding author's E-mail: y.elouadi@ump.ac.ma & h.bendaif@ump.ac.ma

### ABSTRACT

Purpose: The objective of this paper is to make an investigation of spread of novel coronavirus (COVID-19) in MOROCCO and to estimate the duration of confinement for the fight against coronavirus disease 2019 (COVID-19). Methods: Data available on the sites provided by the Moroccan Ministry of Health, nonlinear regression, Gaussian function, residual sum of squares and regression curve. Results: Moroccan citizens must stay at home as much as possible until June 12, 2020. Conclusion: Given the non-existence of a vaccine or an effective treatment against the coronavirus (COVID-19), our research team believes that confinement remains the best solution to limit the spread of this pandemic.

**Keywords:** Pandemic, COVID-19, Investigation, Confinement.

### INTRODUCTION

Recent events have shown us once again, how rapidly and quickly a new disease can take root and spread (Touzani *et al.* 2020; Tuli *et al.* 2020; Wang *et al.* 2020; Nzediegwu *et al.* 2020; Adekunle *et al.* 2020; Zhao *et al.* 2020; Nishiura *et al.* 2020). Since December 2019, pneumonia has attacked 15 Chinese provinces of Hubei (Zhu *et al.* 2019). This pneumonia is the coronavirus (COVID-19) resulting from the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Acter *et al.* 2020; Lombardi *et al.* 2020; Kolani *et al.* 2020; Lahfaoui *et al.* 2020; Casanova *et al.* 2020; Liang *et al.* 2020). Unfortunately, this virus crosses Chinese borders to attack the rest of the world (Isamili 2020, Ahmadi *et al.* 2020; Peters *et al.* 2020).

Saturday April 4, 2020 at 8:00 am (GMT+1), only 4,026 tests had been carried out in Morocco, but after the declaration of the director general of the World Health Organization (WHO) on March 16: "Test, test, test", MOROCCO gradually increased the number of tests. MOROCCO adopts the Polymerase Chain Reaction (PCR) technique for test analysis. This technique is the most reliable, but the slowest and with a unit cost of 500 DH (around 45 euros) each. The technical PCR used is a targeted replication technique *in vitro*. It makes it possible to obtain large quantities of a specific DNA fragment and of defined length from a complex and scarce sample.

In this regard, Morocco has developed a strategy to counter the development of the virus:

On March 2, 2020, Morocco registered the first positive patient for coronavirus on its soil. Since then, the country has embarked on a real race against the clock to avoid the health tragedy. The kingdom barricades its borders,

imposes the closure of schools, universities, non-essential shops, all public places and then declares the cancellation of sporting, cultural and artistic events before closing all the mosques and places of worship.

On March 18, 2020, the Minister of Health called on the population to limit their movements to the maximum and to apply voluntary confinement. March 20, 2020 declaration of a state of health emergency and establishes general confinement which will extend until April 20 at least.

In order to ensure the process and the success of the confinement, the authorities are embarking on a massive awareness campaign, thus non-compliance with the state of emergency is now punishable by one to three months' imprisonment and fines ranging from 300 to 1,300 dirhams (around 117 euros). King Mohammed VI ordered the creation of a fund of more than 30 billion dirhams (around 3 billion euros), dedicated to the upgrading of infrastructure and the acquisition of medical equipment necessary for the treatment of Covid-19, manage the health repercussions, the economic and social impact of the pandemic and pay compensation to employees who are currently in work stopping. The king of MOROCCO, gave his instructions in order to put military medicine in reinforcement of the medical structures of the country, as well as the mobilization of the social services of the Royal Armed Forces and of the gendarmerie.

Since approved by the Food and Drug Administration (FDA) in 1949, chloroquine phosphate, a 4-aminoquinoline synthetic derivative of quinine, received more and more attention of researchers (Conan *et al.* 1950; Djimdé *et al.* 2001), a rich literature of a few tens of thousands of documents is available among the most cited paper of Pear *et al.* (1993) (more than two thousand citations). Recently, Due to his excellent therapeutic activities with regard to Malaria, Didier Raoult strongly defended the use of chloroquine as a drug for COVID-19 (Rolain *et al.* 2007, Devaux *et al.* 2020).

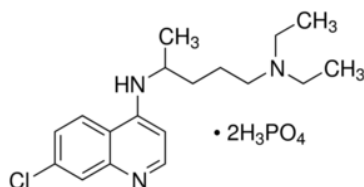


Fig. 1. Molecular structure of chloroquine phosphate.

March 23, 2020, the Minister of Health gave the green light for the introduction of "chloroquine" and "hydroxychloroquine" in the therapeutic management of Covid-19 (Saqrane *et al.* 2020; Hassani *et al.* 2020; Cortegiani *et al.* 2020; Sahraei *et al.* 2020). The Moroccan government has acquired the entire stock of "Nivaquine" and "Plaquenil" medicines (indicated for treating and preventing malaria) which are manufactured at the Sanofi Maroc industrial site in Casablanca. This stock is made available exclusively to health establishments and with a strict protocol of use.

April 7, 2020, Morocco decided the obligation to wear masks to limit the spread of the virus. In addition to the measures taken by the Moroccan state, there are voluntary actions by Moroccan engineers for the manufacture of masks and even respirators.

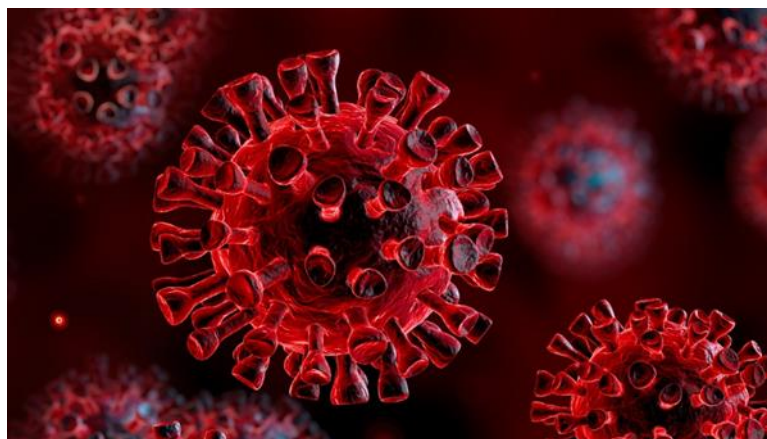


Fig. 2. COVID-19.

In order to not lose the academic season, the Ministry of National Education, Professional Formation, Higher Education and Scientific Research has provided distance learning courses by creating several electronic platforms and even television courses on Moroccan channels for those who don't have internet access. COVID-19 is a new pathogen for humanity, no vaccine or effective treatment are available, so automatically confinement remains the best solution and become an urgent necessity. Given the novelty of this virus and the lack of data, it is difficult to know the necessary duration of confinement to overcome this problem. This work is intended to a various segments of the global community and especially Moroccan society, who are following with great interest and increased awareness the development of the spread of the COVID-19 pandemic, which has infected MOROCCO and different countries of the world. According to our study, we will analyze the case of the spread of COVID-19 in MOROCCO and then, we will try to predict the confinement period sufficient to get rid of this virus.

## MATERIALS AND METHODS

In this study we used the data provided by the Moroccan Ministry of Health. These data are updated three times a day and available on the following sites (<http://www.covidmaroc.ma/Pages/AccueilAR.aspx>; <https://infogram.com/evolution-du-covid-19-au-maroc-1h7d4drq7dlv2nr>). The data from these two sites allows us to assess the spread of COVID-19 in Morocco. Nonlinear regression, Gaussian function, residual sum of squares and regression curve are used to get an estimate of the duration of confinement necessary.

## RESULTS AND DISCUSSION

To better understand the results obtained, we will present them in three sub-paragraphs, starting with 'Data Visualization', then 'Modeling' and ending with 'Model Adjustment'.

### Data Visualization

Table 1 presents the number of positive case in Morocco per day since the virus appeared (2 March) until May 7, 2020.

Fig. 3 shows the evolution of the spread of COVID-19 in MOROCCO.

**Table 1.** Data of the spread of Covid-19 virus in Morocco between March 2 and Mai 7, 2020.

<b>Day</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>	<b>18</b>	<b>19</b>	<b>20</b>
Cases	1	0	0	1	0	0	0	0	1	3	0	2	10	10	9	7	10	9	16	15
<b>Day</b>	<b>21</b>	<b>22</b>	<b>23</b>	<b>24</b>	<b>25</b>	<b>26</b>	<b>27</b>	<b>28</b>	<b>29</b>	<b>30</b>	<b>31</b>	<b>32</b>	<b>33</b>	<b>34</b>	<b>35</b>	<b>36</b>	<b>37</b>	<b>38</b>	<b>39</b>	<b>40</b>
Cases	21	28	27	55	50	58	69	77	77	61	37	54	83	128	102	99	64	91	99	74
<b>Day</b>	<b>41</b>	<b>42</b>	<b>43</b>	<b>44</b>	<b>45</b>	<b>46</b>	<b>47</b>	<b>48</b>	<b>49</b>	<b>50</b>	<b>51</b>	<b>52</b>	<b>53</b>	<b>54</b>	<b>55</b>	<b>56</b>	<b>57</b>	<b>58</b>	<b>59</b>	<b>60</b>
Cases	97	116	102	125	136	259	281	121	170	191	163	237	122	190	139	168	55	132	69	171
<b>Day</b>	<b>61</b>	<b>62</b>	<b>63</b>	<b>64</b>	<b>65</b>	<b>66</b>	<b>67</b>													
Cases	146	160	174	150	166	189	140													

### Modeling

For modeling, we choose a nonlinear regression model written as (C. Ritz, & J. C. Streibig 2009):

$$y_i = f(x_i, \theta) + \varepsilon_i \quad i \in \{1, \dots, n\}, \quad (1)$$

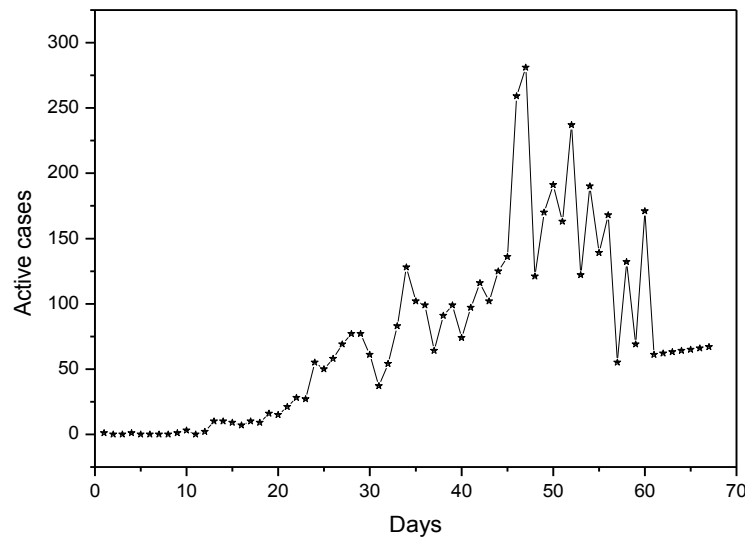
- $n$  : the length of data, in this case it's equal to 67 ;
- $\theta$  : vector of parameters to estimate;
- $\varepsilon_i$ : independent and identically distributed random variables with mean 0 and variance  $\sigma^2$ .

To sum up, the model under study is the following:

$$\begin{cases} y_i = f(x_i, \theta) + \varepsilon_i, & i \in \{1, \dots, n\} \\ \mathbb{V}(\varepsilon_i) = \sigma^2, & \mathbb{E}(\varepsilon_i) = 0. \end{cases} \quad (2)$$

We assume that the spread of the virus Covid-19 is in the form of a Gaussian function, for this reason we choose the following function:

$$f(x, \theta) = \theta_1 \exp\left(-\frac{(x - \theta_2)^2}{2\theta_3^2}\right), \quad \text{Where } \theta = (\theta_1, \theta_2, \theta_3) \quad (3)$$



**Fig. 3.** Evolution of the spread of COVID-19 virus in Morocco between March 2 and May 7, 2020.

### Model adjustment

Please note that the estimates and expectations are subject to change depending on several factors (new data, extent of quarantine application, virus development,...). Therefore, this remains a modest attempt to study the evolution of the virus and give an estimate of the duration of confinement necessary.

Our goal is to give an estimation of  $\theta$ . A natural estimation is given by the minimization of the residual sum of squares. The estimates found are grouped in Table 2.

**Table 2.** Estimate values.

Parameters	Estimated values
$\theta_1$	158.120
$\theta_2$	64.320
$\theta_3$	20.000

We obtain the adjusted model defined by the equation.

$$\hat{y}_i = 96220 \times \exp\left(-\frac{(x_i - 36.215)^2}{259191}\right) \quad \text{with } i \in \{1, \dots, n\}.$$

(4)

According to the regression curve, we can deduce the following results:

- ✓ The peak day may be May 10, 2020 with approximately 200 confirmed cases.
- ✓ The number of expected cases can reach 9000 positive cases.
- ✓ Estimated confinement duration to overcome the danger phase is until 12 June, 2020 + 15 days\*.

\*: The time required to determine contacts of the last infected case.

**NB.** We note that the peak day may change if MOROCCO adopts another method of analysis of COVID-19, especially if it is going to import from South Korea a rapid analysis technique which does not exceed thirty minutes. Note that at the time of deconfinement, the number of positive cases can increase significantly if citizens don't comply with the security requirements previously used.

With time, we have started to have a clear picture of the importance of the measures taken by the Moroccan State at all political, economic and security levels to fight against the spread of the Corona virus COVID-19. Morocco, king, government and people, enlisted to cope with overcoming the repercussions of this pandemic. Analysis of these results shows positive signs that can be described as a global revolution for Moroccans against the pandemic of the third millennium.

According to the Moroccan Ministry of Health, the first appearance of the virus was on March 02, 2020. The first positive case detected in Morocco was coming from Europe, specifically from Italy. This can be explained by Morocco's geographical proximity to Europe.

Usually we can deduce that the development of the COVI-19 pandemic goes through four stages:

- i) Entry stage of the virus.
- ii) Incubation stage of the virus.
- iii) The stage of widespread of infection.
- iv) What was accomplished in the third stage is either its completion or the total loss of control.

Inspection of Table 1 and Fig. 3, we can clearly see the first and second stages and the beginning of the third, which is the spread phase of COVID-19. During the third stage, the virus is very strong and spreads quickly, the reason why the number of positive cases is high compared to the days before, such agreed with literature findings (Nicol *et al.* 2017; Orefice *et al.* 2019; Smia *et al.* 2020).

Based on equations 1, 2, 3 and 4, we found that May 10, 2020 is the peak day (day corresponds to the largest number of positive cases detected). The number of positive cases can reach up to 9000. While the most important is the estimation of the duration of the confinement necessary to arrive at zero positive cases detected. At this stage, if the measures taken by the Moroccan state have been respected and applied properly, the authors of this article estimated that the confinement should be extended until June 12, 2020 + 15 days \* (\*: The time required to report the last infected case).

## CONCLUSION

Of course, the confinement will have negative repercussions on the various vital sectors in the country, including what is political, economic, social and also negative effects on the psyche of the Moroccan citizen. But the primary goal remains to overcome this scourge with the least possible losses, in order to ensure the safety and continuity of life humanity.

Following our research, the Moroccan population is recommended to adhere to confinement until June 12, 2020 + 15 days to arrive at the regression of the pandemic, the extinction of the COVID-19 virus and return to the situation normal in our country.

**ACKNOWLEDGMENT:** None.

**Financial support:** None related to the content of this manuscript.

**Conflict of interests:** None related to the content of this manuscript.

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## بررسی گسترش کرونا ویروس جدید (COVID 19) دنیاگیر شده در مراکش و تخمین دوره قرنطینه برای غلبه بر مرحله خطر

ا.چ. بندایف\*<sup>۱</sup>، ب. هموتی<sup>۲</sup>، آ.ی. استیان<sup>۳</sup>، وای. بندایف<sup>۳</sup>، م. آ. القادی<sup>۴</sup>، وای. القادی\*<sup>۲</sup>

- ۱- آزمایشگاه شیمی آلی، فرآورده های ماکرومولکول و طبیعی، دانشکده علوم، دانشگاه محمد فرست، اوجدا، مراکش  
 ۲- آزمایشگاه شیمی تجزیه کاربردی، مواد و محیط زیست (LCA2ME)، دانشکده علوم، دانشگاه محمد فرست، اوجدا،  
 مراکش  
 ۳- گروه ریاضی، دانشکده علوم، دانشگاه محمد فرست، اوجدا، مراکش  
 ۴- مهندس مدرسه ملی معادن رباط، مراکش

(تاریخ دریافت: ۹۸/۰۲/۱۸ تاریخ پذیرش: ۹۸/۰۷/۱۵)

### چکیده

اهداف، هدف این مقاله بررسی گسترش کرونا ویروس جدید (COVID 19) در مراکش و تخمین دوره قرنطینه برای مقابله با بیماری کرونا ویروس ۲۰۱۹ (COVID 19) است. روش ها: دیتای مورد استفاده در این بررسی از وزارت بهداشت مراکش تأمین شد. از آزمون غیر خطی رگرسیون، فانکشن گوس، جمع باقیمانده مربعات و منحنی رگرسیون استفاده شد. نتایج: شهروندان مراکش باید باید تا آنجا که ممکن است در قرنطینه تا ششم ژوئن ۲۰۲۰ بمانند. نتیجه گیری: به لحاظ عدم وجود واکسن یا درمان مؤثر در مقابل کرونا ویروس (COVID 19) گروه تحقیقاتی ما اعتقاد دارد که قرنطینه بهترین راه حل برای محدود کردن گسترش این دنیاگیری است.

\*مؤلف مسئول

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### *Bibliographic information of this paper for citing:*

Bendaif, H, Hammouti, B, Stiane, I, Bendaif, Y, El Ouadi, M, A, El Ouadi, Y 2020, Investigation of spread of novel coronavirus (COVID-19) pandemic in MOROCCO & estimated confinement duration to overcome the danger phase. Caspian Journal of Environmental Sciences, 18: 149-156

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