STIMR Model for Covid 19 Pandemic

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ABSTRACT

In this work, we are interested in proposing a mathematical model for the evolution of the pandemic of covid 19. And this in order to answer the question of the control of this pandemic, by giving the spade number of infected people and the duration of the fight against this pandemic.
If we talk about the place and Duration of Study, as you Know, and because of the confinement, we were forced to work remotely between Finance, Entrepreneurship and Development laboratory, Faculty of Legal, Economic and Social Sciences of Sale, and Engineering Systems and Applications Laboratory, National School of Applied Sciences of Fez, between March 02, 2020 and April 16, 2020.

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In first, we start by giving a proposed mathematical model for the covid 19 pandemic. We demonstrate the existence and uniqueness of solution for this model. Second, we give graphic results for this modeling with a detailed reading of these results in order to facilitate to our doctors and biologists to take the necessary measures for stopping this pandemic.

Among the 10000 healthy people, and by carrying out a rate tests which reaches 2/3, we will be able to have the highest number (spade) of the infected people after 60 days with 2000 infected, without forgetting the medical treatment. And, after 170 days, we can say that we have 0 infected.

In the end, we can say that we participated in this global cadence to give control scenarios for covid 19 pandemic by proposing a one of several models that modeling this pandemic. We can give a well-developed model when the world finds a vaccine for this pandemic, then we will modify our model for adapting this new.

1 INTRODUCTION

Since January 2020, the media has reported the emergence of a mysterious viral pneumonia in Wuhan, China. Today we know the culprit: the SARS-CoV-2 corona virus. Since then, the world has been exposed to a continuous flow of information regarding its spreading capacity and its impact on mortality. Although a significant part of the mystery has been revealed, the prediction of the spread of the virus remains difficult while many uncertainties remain about it (see [1],[2],[3]). As part of the fight against this virus, mathematical models help us understand the spread of the virus and allow us to assess the effects of the interventions undertaken to limit its spread, with one major goal: to flatten the epidemic spade in order to keep it under health system capacity (see [4]).

Recent models of SARS-CoV-2 are often derived from the famous SIR model developed in 1927 by Kermack and McKendrik (see [5],[6],[7],[8],[9]), which describes the transition between populations of Susceptible (S), Infectious (I) and Recovered (R) individuals. **Susceptible** individuals are not immune to the contagious agent. **Infectious** individuals are infected and, without necessarily being sick, can infect other **Susceptible** individuals. **Recovered** individuals are immune to the disease after fighting it (see [10]). In the case of SARS-CoV-2, it would be useful to add a population of Exposed (E) individuals to the model to make our study more efficient.

In this work, we will focus on modeling this pandemic for the case of Morocco, in order to benefit from the examples of other countries that have been able to stop the spread of the virus. Successful example of the fight against this virus is the German example. These country which have been able to successfully control contamination between people from the increase in the number of tests done per day to detect infected people and put them away.

So we took this measure into account to determine our mathematical model with compartments using the simple SIR model with the addition of a compartment which determines the number of estimated tests performed per day and the influence of this information on the control of number of infected in Morocco.

2 THE COMPARTMENTS PROPOSED MODEL

In this section we deal to give a compartments proposed model to Covid 19 pandemic for the general case (see [11], [12]) and especially for Morocco. First, with the experience for many example of pandemics, the number of medicals tests has a big impact for controlling the number of infectious. Also, the using medical protocol has a direct impact in the number of recovered.

2.1 The Proposed Model

In consideration of all we are saying before, and before defining our proposed model, we need to

talk about two important coefficients, the first is linked to the reliability of the tests in relation to the total number of susceptible, and the second the reliability of the tests to detect the infected among susceptible. Then, the proposed model **STIMR** (S:Susceptible, T: Tests, I: Infectious, M: medical treatment, R: Recovered) for modeling the covid 19 pandemic is given by:
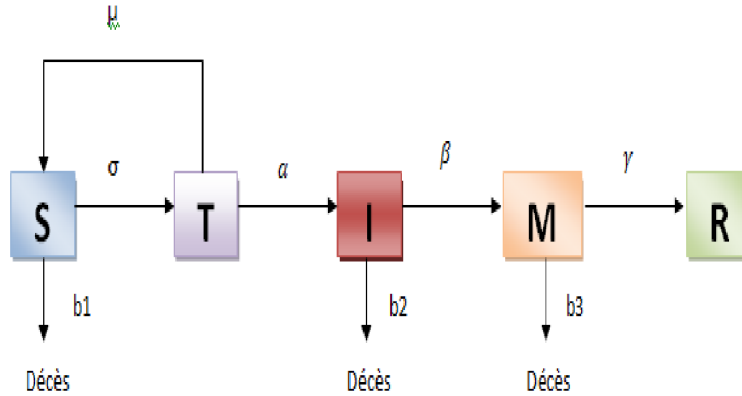

Fig. 1. Compartments proposed model

and we define the equation of this proposed model as:

$$\begin{cases} S'(t) = -\sigma S(t)T(t) + \mu T(t) - b_1 S(t) \\ T'(t) = \sigma S(t)T(t) - (\mu + \alpha) T(t) \\ I'(t) = \alpha T(t) - (\beta + b_2) I(t) \\ M'(t) = \beta I(t) - (\gamma + b_3) M(t) \\ R'(t) = \gamma M(t) \end{cases} \quad (2.1)$$

with:

σ: is the test rate;

μ: is the rate of tested people who are healthy;

α: is the rate of infected people;

β: is the rate of infected people who have undergone medical treatment;

γ: g is the rate of recovered people after medical treatment;

b_1, b_2 and b_3: are respectively the mortality rates for healthy people, infected people and people under medical treatment.

Now, to continue our mathematical modeling, we will need to define our recovery rate. We notice: The reliability of the tests in relation to the total number of susceptible:

$$R_T = \frac{\sigma}{\alpha + \mu}$$

The reliability of the tests to detect the infected among susceptible:

$$R_I = \frac{\alpha^2}{\beta + b_2} - 1$$

Then we deduce the recovery rate definition as:

$$R_0 = R_T + R_I$$

2.2 The Existence and Uniqueness of Solution of the STIMR Model

In this part, we need to demonstrate that our mathematical model is well posed. For this, we have the following theorem.

Theorem 2.1. *The mathematical model (2.1) is well posed.*

Proof. We define the function f as follow:

$$f : \mathbb{R}^n \to [0, 200] \times \mathbb{R}^n$$

$$y(t) \longmapsto f(t, y(t)) = A.y(t)$$

with:

$$y(t) = \begin{pmatrix} S(t) \\ T(t) \\ I(t) \\ M(t) \\ R(t) \end{pmatrix}$$

and

$$A = \begin{pmatrix} (-\sigma T^* - b_1) & \mu & 0 & 0 & 0 \\ \sigma S^* - (\alpha + \mu) & 0 & 0 & 0 & \\ 0 & \alpha & -(\beta + b_2) & 0 & 0 \\ 0 & 0 & \beta & -(\gamma + b_3) & 0 \\ 0 & 0 & 0 & 0 & \gamma \end{pmatrix}$$

We define S^* and T^* as fixed parameters of S and T.

To verify that the problem is well posed, we demonstrate that the function f is a lipschitz function (see [13]).

Let $y_1(t)$ et $y_2(t) \in \mathbb{R}^n$, we have:

$$||f(t, y_1(t)) - f(t, y_2(t))||_{\mathbb{R}^n} = ||A.y_1(t) - A.y_2(t)||_{\mathbb{R}^n}$$

$$||f(t, y_1(t)) - f(t, y_2(t))||_{\mathbb{R}^n} \leq ||A||_{M_{5 \times 5}(\mathbb{R})} ||y_1(t) - y_2(t)||_{\mathbb{R}^n}$$

with $||.||_{\mathbb{R}^n}$ the standard of $\mathbb{R}^n$, and $||.||_{M_{5 \times 5}(\mathbb{R})}$ the matrix standard in $M_{5 \times 5}(\mathbb{R})$.

Then, we verify that f is Lipschitz function, so the problem (2.1) admit a unique solution. which means that the proposed mathematical model is well posed. □

3 NUMERICAL RESULTS

In this section, we will see the graphics results for the general case, and Moroccan case.

All these results are achieved by Scilab Software. We fixed the value of all parameter:

$\sigma = 2/3$
$\mu = 1/20$
$\alpha = 1/2$
$\beta = 2/3$
$\gamma = 1/3$

$b_1 = 0$
$b_2 = 0$
$b_3 = 1/3$

and we define the legends used in the graphs as follows :

Personnes Saines: Healthy People
Personnes infectes: Infected people:
Tests effectus: Tests performed:
Personnes guries: People healed:

3.1 General Case

For this case, we considered that we started with one infected case and zero test.

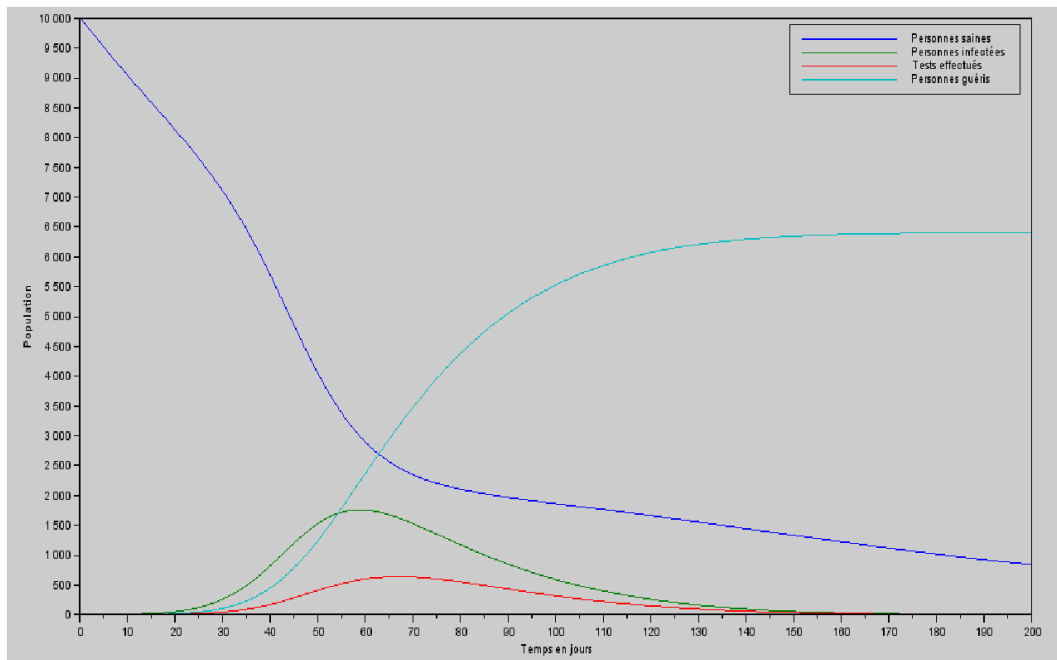Also, we proposed that after the third infected case, we started the medical treatment. And we have:

Fig. 2. General case for STIMR model for covid 19

As we see, in the figure, among the 10000 healthy people, and by carrying out a rate test which reaches 2/3, we will be able to have the highest number (spade) of the infected people after 60 days with 2000 infected, without forgetting the medical treatment. And, after 170 days, we can say that we have 0 infected.

3.2 Moroccan Case

Now, we focus to the Moroccan case. This numerical treatment is based on statistics provided by the Moroccan Ministry of Health. We note that the number of tests carried out by the Ministry of Health is

still insufficient, for example, in the 23 days; we counted 334 tests on 1 days.

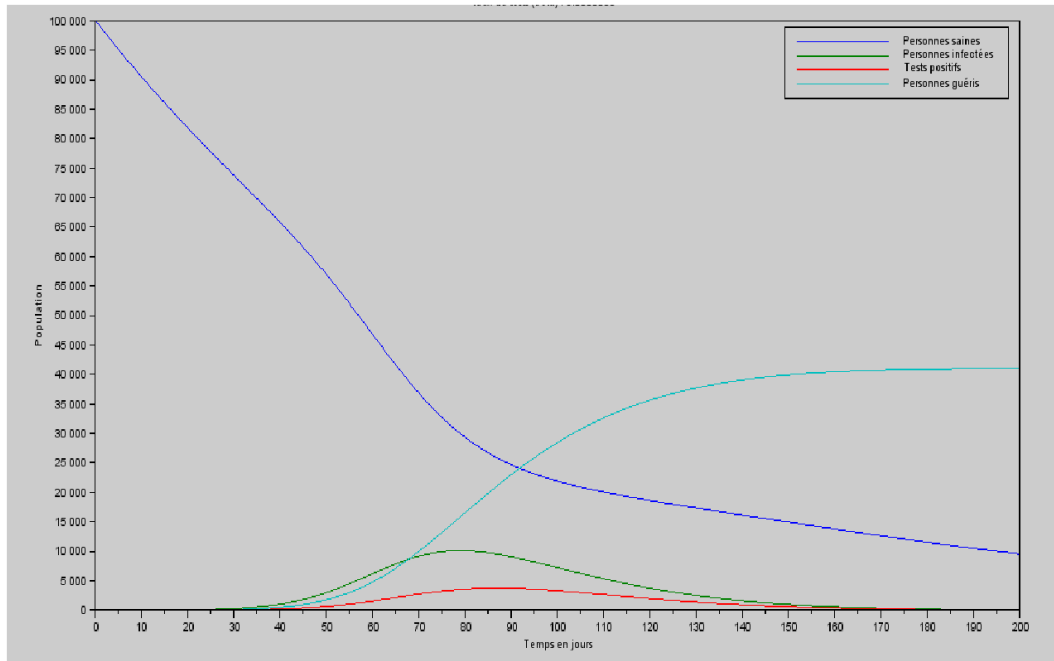We started with 1 infected case in this simulation, and we have:

Fig. 3. Model STIMR for covid 19 for Morrocain case

First, the choice of sample size (100000 persons) is based on the remark of the uncertainty of the test numbers at the beginning of this pandemic, and then we cannot control the numbers of infected person.

Second, to control this simulation, we minimized the number of tests per days with 100 tests, and we gave an average of 500 tests per day.

For this, we remark that the highest number (spade) of the infected people reaches 9000 persons after 75 days.

So, if we want to reduce this period and the number of infected people, we need to double the number of test per day, and up to 1000 tests per days. Also, in this paper, we need to congratulate the Moroccan authorities for the rapid decisions it has taken to control this pandemic, namely the closing of the borders, which has helped to minimize the external contamination.

As a note, all the parameters given for these graphs are calculated from statistics provided by the World Health Organization.

4 CONCLUSIONS

As a conclusion, this work has been devoted to study the covid 19 pandemic evolution, and give a one of several models that modeling this pandemic.

We can give a well-developed model when the world finds a vaccine for this pandemic, and in this case, we will redo our work by considering this new information.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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