Original article:

Impact of containment type on Covid-19 propagation in Morocco using the SIR model.

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Abstract

Objective and mehtods: Our objective is to determine the containment effect on the spread of Covid 19 in Morocco. The methodology is based on an epidemiological study whose objective is to take stock of the current situation and to estimate the future spread of Covid-19 over time in Morocco. Several conditions were considered using the SIR epidemiological model for a better reliability of the results. During the study period from the appearance of the first case until 19 June 2020, Morocco reported 9074 cases of infections, 213 deaths with a lethality of 2.35% and a mortality of 6.04 per million inhabitants. ***Results and Conclusion***: The results of the SIR model show a sudden increase in infections. The peak would be 4.4 million inhabitants or 12% of the total population under confined conditions. Selon ces résultats,Containment is one of the most effective methods of reducing the risk of infection.

Keywords: Impact, containment, type, Covid-19, propagation, SIR model,Morocco.

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Introduction

Containment remains one of the most effective methods to curb the spread of viruses today. Since the detection of the first real case of coronavirus (Covid-19) on March 2, 2020, the Moroccan authorities have taken a large number of decisions to limit the spread of the pandemic and preserve the health and safety of citizens. They therefore decided to declare a «state of health emergency» and took a series of swift and strict measures against the Covid-19. All Moroccan cities have been closed and the majority of industrial and commercial activities have been forced to cease their activities until further notice. Likewise, the populations were invited to stay at home and only go out in the event of authorized specific needs (purchase of basic necessities, medical consultations, etc.). In addition to these security measures, the authorities have also decided to close transport and travel inside and outside the country, to close schools, universities, restaurants and mosques, and to ban mass gatherings throughout Morocco[1]. On June 20, 2020, it was decided to extend the containment status, first until June 11, 2020 and then until July 10, 2020 with regional relief from the restrictions.

At the time when Morocco is preparing for deconfinement, it seemed necessary to us to estimate the spread of the virus over time in Morocco according to several conditions according to the states of strict confinement to the states of deconfinement and to model projections according to various parameters related to the spread of the virus.

In order to reach these objectives, we will therefore draw the real curves of the evolution of the number of infections and remissions during the study period, as well as the number of screenings carried out since the appearance of the first case until ‘’ as of June 19, 2020. We will also draw up forecasts of the evolution of covid-19 according to several deconfinement situations based on the SIR epidemiological model.

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This model makes it possible to better understand the epidemic and to foresee the period and the means of lifting the restrictions imposed by the state of health emergency.

Methods

The data we used is that which is published daily by the WHO website [2]. These data relate in particular to the number of infected cases, the number of deaths and the number of remissions since the appearance of the first imported case on March 2, 2020 until June 19, 2020 [2]. The methodology is based on an epidemiological study whose objective is to take stock of the current situation and to estimate the future spread of Covid-19 over time in Morocco. Several conditions were considered using the SIR epidemiological model[3]for better reliability of the results. The epidemiological model «S.I.R» was presented for the first time by KERMACK & McKENDRICK in London and Cambridge in 1927 to explain a posteriori the evolution of the epidemic of plague in Bombay in 1905-1906 [3].

The principle of this model is based on the fact that at every instant t, the population is subdivided into three compartments S, I and R defined by the functions S (t), I (t) and R (t) so that :

- S is the number of Susceptibles: It is made up of individuals who have never had the disease but who can contract it;
- I is the number of infected cases: It is made up of individuals who have contracted the virus, and are therefore contagious;
- R is the number of Recovered: It is made up of individuals who have already contracted the disease and are now immunized following their recovery, and deceased individuals who can no longer transmit the virus to those around them.

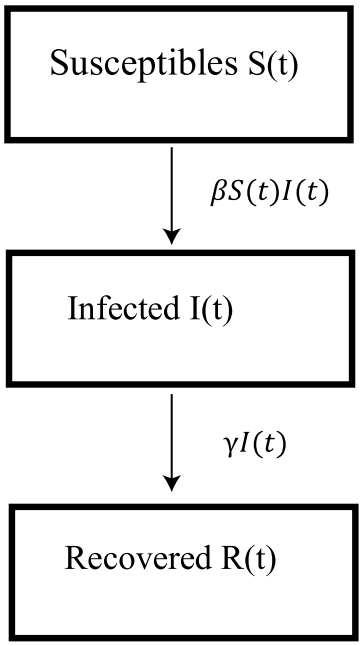
Let us consider S (t), I (t) and R (t) the respective proportions of individuals in each of the categories composed respectively of healthy individuals, infected individuals and individuals recovered or deceased at time t.

The size of each group constitutes a random variable, which can be modeled according to a function of the independent variable «time» expressed by t so that we will have S (t), I (t) and R (t). During the spread of the virus and the evolution of the epidemic, the size P of the total population can be considered constant at time t, we write then[4] :

$S(t) + I(t) + R(t) = P$ [5-6-7].

The choice of this model is based on the fact that it is the most classic epidemic method for analyzing infectious diseases. It is performed at a defined latency period, and has proven to be predictive for several varieties of acute infectious diseases in the past such as Ebola and SARS [8-9-10-11-12-13-14]. This model has also been used for the estimation of Coronavirus 2019 cases in Wuhan [15].

Thus, and in order to model the dynamics of COVID-19, we will use three differential equations each characterizing the change in each of the three groups of the SIR system previously raised and which model the spread of an infectious disease. An equation characterizing the population dynamics from one group to another, where β is the parameter that controls the transition between S and I and ɣ the one that controls the transition between I and R:



$$\frac{\Delta S}{\Delta t} = S(t+1) - S(t) = -\frac{\beta(t)s(t)I(t)}{P}$$

$$\frac{\Delta I}{\Delta t} = I(t+1) - I(t) = \frac{\beta(t)s(t)I(t)}{P} - \gamma(t)I(t)$$

$$\frac{\Delta R}{\Delta t} = R(t+1) - R(t) = \gamma(t)I(t)$$

It should be noted that, according to this model, the recovered individuals are considered to be immune and cannot be infected again.

Results

During the study period from the appearance of the 1st case until June 19, 2020, Morocco reported 9074 cases of infections, 213 deaths with a lethality of 2.35% and a mortality of 6.04 for a million

inhabitants. The high recovery rate of 88.62% is observed following the use of the therapeutic protocol of chloroquine and azithromycin. Similarly, we noted a significant lethality in the period from March 30 to April 05, 2020. We have reported in Table I, the results concerning the spread of the epidemic virus during the study period week by week.

Table 1: Distribution of the number of cases covid-19, number of deaths, number of cures, incidence, fatality and mortality rates

Week	Case	Death	Cured	Incidence P Million	Lethality %	Mortality P Million	Number of screenings
02-08 march	02	00	00	0,06	0,00	0,00	62
09_15 march	26	01	01	0,74	3,85	0,03	90
16-22 march	87	03	02	2,47	3,45	0,09	482
23-29 march	364	22	10	10,33	6,04	0,62	1639
30 march-05 Apr	542	44	63	15,38	8,12	1,25	2575
06-12 April	640	48	101	18,16	7,50	1,36	3756
13-19 April	1194	23	150	33,88	1,93	0,65	6519
20-26 April	1210	20	266	34,34	1,65	0,57	12276
27 Apr-03 may	838	13	845	23,78	1,55	0,37	14713
04 – 10 may	1160	14	1107	32,92	1,21	0,40	23812
11-17 may	807	04	1115	22,90	0,50	0,11	24033
18-24 may	563	07	1043	15,98	1,24	0,20	52925
25-31 may	374	06	756	10,61	1,60	0,17	66247
01-07june	417	03	1887	11,83	0,72	0,09	96824
08-14 june	569	04	419	16,15	0,70	0,11	116567
14-19june	487	01	316	13,82	0,21	0,03	83116
Total	**9074**	**213**	**8041**	257,48	2,35	6,04	505636

These results allowed us to draw the curves of the evolution of the parameters S which represents the general population, I which represents the number of infected individuals and R which represents the total of remissions composed by the sum of deaths added to the cure rate(figure 1).

We have shown in Figure 1 the 3 parameters of the SIR system during the 111 days of the epidemic. Thus, there is a parallel evolution between the number of cases (I) and the number of remission (D + G). This rate was 90.48% on June 19, 2020.

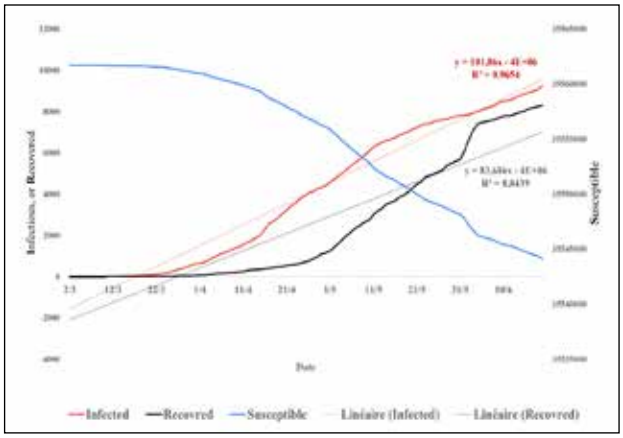


Figure 1 : Evolution des paramètres SIR au cours de la période d'étude

With the progression of the Covid-19 epidemic, the measures to stem its spread are more and more drastic. Closed schools, canceled events and confinement have become common. These measures can only be effective if the state carries out mass screening. Screening for the virus is an important factor in limiting its spread and successful containment strategies. In this regard, Morocco has decided to gradually increase the number of screening. Figure 2 shows the evolution of the number of screenings carried out since the start of the epidemic to date.

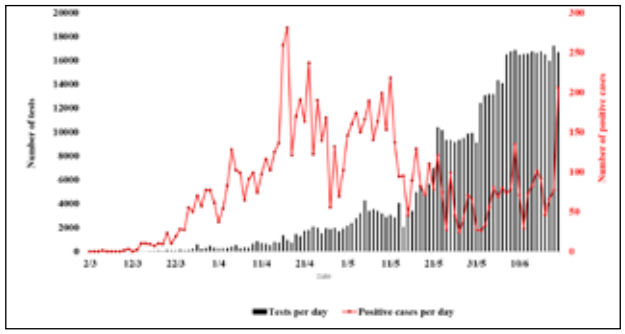


Figure 2: Distribution of negative and positive cases of COVID-19 in Morocco according to the tests performed per day

It should be noted that 488,947 PCR screening tests were performed from March 2 to June 19, 2020, with an average of 4,485.75 tests / day during the study period from March 2 to June 19 2020 and an infection rate of 1.86%. This number of screenings places Morocco second in Africa, after South Africa. Their results which we have just exposed suggest that the current restrictions have made it possible to decrease the potential number of cases in the country, Morocco has indeed avoided an explosion of the cases of infection during this period. Preparations for deconfinement are underway and it seemed appropriate to us to model the evolution of the

epidemic in Morocco to better understand the effect of confinement on the speed of spread of Covid-19 in Morocco. We thus estimated the spread of Covid-19 using the SIR epidemic model. To do this, we set up three scenarios depending on the contact rate (C) and the duration of infection (D).

Thus, we have used for our estimates the contact rate 3, corresponding respectively to a strict confinement, the contact rate 5 which corresponds to a deconfinement with rigor of the measures of hygiene, distance and wearing of mask and the rate of contact 12 which corresponds to reduced measures during deconfinement. For each scenario, we set two durations of infection D = 7 and D = 14; which correspond to the durations listed in the literature.

We will present in the following the results corresponding to the 3 scenarios raised.

- Scenario 1: The contact rate C = 3

In this first scenario, we have very strict control and respect of the instructions for exceptional exits with authorization and absolute prohibition to circulate between 17:00 and 05:00 in the morning, as is the case during this confinement period. The projections concerning this scenario for the two durations of infection 7 and 14 are shown diagrammatically in the figure 3.

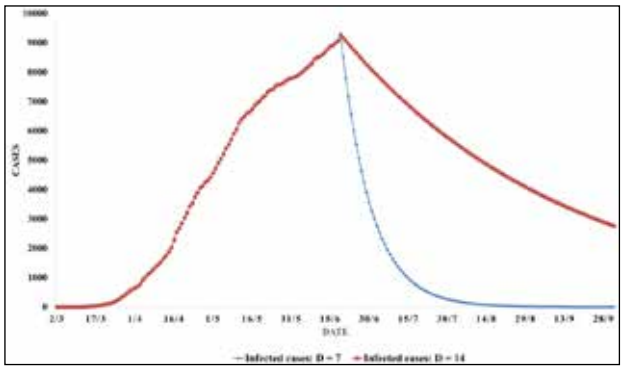


Figure 4: SIR model applied in Morocco - Scenario 1

In this first scenario, the results of our projection show a rapid decrease for the two durations of infection D = 7 d and D = 14 d. This model shows that the epidemic will be completely eradicated during the second week of July for the first case and two to three months later for the second infection rate. We believe that Morocco, which has planned deconfinement on July 10, 2020, is in the conditions of D = 7 days following the therapeutic protocol using chloroquine (or hydrochloroquine) associated with azithromycin generalized to all positive cases screened whether symptomatic or asymptomatic.

- Scenario 2: The contact rate = 5

In this second scenario, we consider a deconfinement from July 10 but a very strict application of the measures of distancing, hygiene and wearing of masks. We estimated in this scenario that the contact rate would be 5 since gatherings exceeding 50 people are prohibited and schools and universities remain closed until September.

The results of this scenario, which we have recorded in the figure, show a rapid decrease in the number of cases for a duration of infection D equal to 7 days and an eradication of the epidemic at the beginning of September. We think it is this scenario that is most likely to happen in Morocco.

The case of D14 shows an increase in the rate of infection which will reach a peak of 25,000 cumulative cases of Covid-19 disease at the end of September 2020. Under these conditions, the epidemic will last until the beginning of 1 year 2021 in case there is not a second wave of virus virulence.

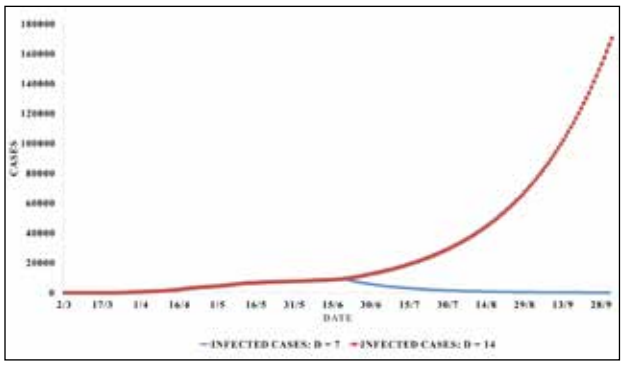


Figure 5: SIR model applied in Morocco - Scenario 2

- Scenario 3: The contact rate = 13

This third scenario represents the projection of the Covid-19 according to the SIR model under the conditions of brutal deconfinement as a measure of distance and / or hygiene. This scenario corresponds to a normal resumption of activities.

The results of this diagram, which we have represented in FIG. 5, show a sudden increase in cases of infections. The peak would be 4.4 million inhabitants or 12% of the total population for the duration of infection of 7 days and 13.6 million inhabitants for D = 14 days. The two peaks would be reached on August 9 and July 24 respectively for the two infection rates. In both cases, the epidemic is expected to disappear in early October, but if the symptomatic infection rate is high, the health system may be exceeded and the cost in human life would be very high.

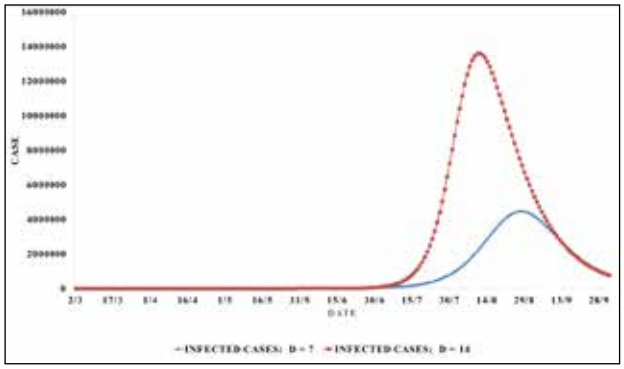


Figure 6: SIR model applied in Morocco - Scenario 1

Discussion

In this study, we traced the epidemiological profile of COVID-19, as well as its spread over time in Morocco according to the Model (SIR). The results show that the epidemiological situation of this pandemic is not as alarming in comparison with other neighboring countries such as Algeria, Spain or France [2].

Indeed, the overall transmission rate during the months of March and April 2020 in Morocco is between R0 = 0.9 and R0 = 1, as well as a decrease in the positive cases of Covid-19 observed during the last weeks of April and the first weeks of June 2020. This leads us to believe that COVID-19 represents a minor pandemic on a national scale in comparison with other countries.

Unlike other European countries, notably Italy, where this rate represented 1.8 during the March period, which explains why an infected person can infect two individuals[16]. In addition, at the international level, the WHO Regional Director for Europe said that the number of cases should increase further. He urged countries to continue implementing a containment strategy while accelerating their efforts to fight the disease. It is essential to act quickly and every day can make a difference [18].

As for the National situation, the Moroccan Ministry of Health has reported 9,074 cases since the first imported case from March 2, 2020 until June 18, 2020, with a higher concentration in large cities.

Thus, and according to data from the Ministry of Health, the Casablanca-Settat region represents approximately 32.66% of the covid-19 cases observed, followed by the Marrakech-Safi region with a rate of 18.26%. The high number of positive COVID-19 cases in these two regions could be explained by the high density of the urban population. This high density constitutes a risk factor for the spread of this pandemic both in Morocco and in Africa [17]. In addition, these regions have the distinction of hosting a strong industrial activity, which is the source of professional homes. Conversely, regions with low population density and low industrial activity have experienced only very low contamination rates. This finding is supported by the epidemiological situation in the 4 regions of southern Morocco did not exceed the rate of 1% of infections.

As for lethality, it only represents 2.2%, this could be influenced by several factors such as gender and age. Previous studies have suggested that an increased age is associated with death in patients with SARS-CoV-1, MERS and COVID-19 [19-20-21]. Regarding gender, one study found that COVID-19 was more likely to affect men than women, and symptoms appeared to be more severe in men[22]. This could be explained by the reduced susceptibility of females to SARS-CoV-2 infections, due to the protection of X chromosomes and sex hormones including the presumed role of innate and adaptive immunity[23]. Indeed, previous studies have found higher percentages of SARS-CoV-1 infection in male mice compared to female mice and have provided mechanistic information related to estrogens [24].

In order to measure the propagation of COVID-19 as a function of time, we used the SIR model. Two scenarios are assumed, the first with a high contact rate (without containment) and the second with a low contact rate (with containment). According to this model, Morocco is assumed to be situated in the scenario where the pandemic is minor. Indeed, the results of this study show that strict containment is one of the effective methods of reducing the numbers of newly infected cases and controlling the pandemic situation of COVID-19.

Estimates of the risk of transmission and the epidemiological peak of COVID-19 are of great interest since they make it possible to reinforce the vigilance of political decision-makers and give a preventive vision, the objective of which is to protect the public population against the spread of this epidemic. To estimate the number of propagation of cases affected by the coronavirus, several parameters were calculated such as the number of reproduction «R». Indeed, the number of reproduction “R” which measures the transmissibility of a virus, represents the average number of new infections generated by each infected person, whose initial constant is called the basic number of reproduction “R0” [25]. According to studies by Read[26], the R0 for the COVID-19 epidemic is much higher than that of other emerging coronaviruses. Under these conditions, it would be very difficult to contain or control the spread of this virus. Indeed, if preventive and control measures

were not sufficient or if new factors occurred, a large proportion of cases with mild or no symptoms would exist in the community and the epidemic could continue to develop at a high rate. speed. According to the epidemiological study carried out by the Ministry of Health, the number of basic reproductions R0 was estimated at 2.2 before confinement [27].

Finally, pharmacologically, Morocco was one of the first countries to establish a therapeutic protocol for the treatment of Covid-19 disease. Indeed, the Ministry of Health consulted with a technical and scientific medical committee which recommended the treatment of people infected with the combination of chloroquine and azithromycin, a macrolide antibiotic, according to the ministerial note. Chloroquine and its hydroxylated derivative hydroxychloroquine are old drugs with antimalarial properties, the use of which has gradually been restricted with the appearance of strains of Plasmodium falciparumchloroquino-resistant. They also have anti-inflammatory and immunomodulatory activity by regulating the production of TNFα, interferon and certain cytokines. These properties mean that hydroxychloroquine is indicated in certain autoimmune diseases, such as lupus or rheumatoid arthritis [28-29].

Conclusion :

In conclusion, our results based on the epidemiological situation in Morocco are in harmony with the WHO strategy which recommends the following recommendations `` it is always possible to stop the spread of the virus, provided that the countries put in place measures energetic to detect the disease early, isolate and treat cases, find contacts and promote social distancing measures commensurate with the risk '' [30].

The added value of the study

The added value of our study is the determination of the effect of containment on the reduction of the spread of COVID-19, thus giving a general idea of the epidemiological situation of this pamdemic in Morocco with the objective of providing health strategies for the Ministry of Health.

Source of fund:

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Conflict of interest:

No conflict of interest

Ethical clearence:

Our study respects the ethical aspects declared by the University Ibn Tofail of Kenitra, so we kept the anonymity of the patients.

Authors's contribution

NL was involved in the study design and data collection. contributed to the design, analysisand interpretation of the study and then critically reviewed the manuscript. ZA primarilyanalyzed the data and verified the methods of analysis. researched related documentation,wrote the literature review and finalized the manuscript. SJ contributed to the design of thestudy, interpreted the data and reviewed the manuscript. AM and AS contributed to the studydesign and oversaw the entire study process. All authors read and approved the finalmanuscript.

References:

1. Otmani A, Benchrif A, Tahri M, Bounakhlab M,El MahjoubC, El BouchcM ,Krombid M. Impact of Covid-19 lockdown on PM10, SO2 and NO2 concentrations in Salé City (Morocco).Science of The Total Environment.2020 ;735(15) : 139541.
2. World Health Organization. COVID-19 in the WHO African Region.Consulted (19/06/2020).Availablefrom : https://www.afro.who.int/health-topics/coronavirus-covid-19.
3. Ogilvy Kermack W, A. G. McKendrick. A contribution to the mathematicaltheory of epidemics. [Cited 18 avr 2020]. Available on: https://royalsocietypublishing.org/doi/10.1098/rspa.1927.0118
4. Li, Q. et al. Early transmission dynamics in Wuhan, China, of novel coronavirus–infectedpneumonia. N Engl J Med. 2020 ; 26;382(13):1199-1207. Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potentialdomestic and international spread of the 2019-nCoV outbreakoriginating in Wuhan, China: amodellingstudy. Lancet. 2020; 395(10225):689-697.
5. Chowell, G., Nishiura, H. & Bettencourt, L. Comparative estimation of the reproduction number for pandemic influenza fromdaily case notification data. J R Soc Interface. 2007; 4(12): 155–166.
6. Chowell, G., Hengartner, N. W., Castillo-Chavez, C., Fenimore, P. W. & Hyman, J. M. The basic reproductive number of ebola and the effects of public health measures: the cases of Congo and Uganda. J Theor Biol. 2004;229(1):119-26.
7. Fang, H., Chen, J. & Hu, J. Modelling the SARS epidemic by a lattice-based Monte-Carlo simulation. Conf. Proc. IEEE Eng. Med Biol. Soc 2005; 7(3):7470–7473.
8. Chen, SC, Chang, C.-F. & Liao, C.-M. Modèles prédictifs de stratégies de contrôle impliquées dans la maîtrise des infections aéroportéesintérieures. Air intérieurp 2006:16, 469-481.
9. Getz, W. M., Salter, R. &Mgbara, W. Adequacy of SEIR models whenepidemics have spatial structure: Ebola in Sierra Leone. Cited (02/06/2020).Availableon: https://doi.org/10.1098/rstb.2018.028 .
10. Smirnova, A., deCamp, L. &Chowell, G. Forecasting Epidemics Through Nonparametric Estimation of Time-Dependent Transmission Rates Using the SEIR Model. Bull. Math. Bull Math Biol. 2019 Nov;81(11):4343-4365
11. Saito, M. M. et al. Extension and verification of the SEIR model on the 2009 influenza A (H1N1) pandemic in Japan. Math Biosci. 2013 Nov;246(1):47-54.
12. Peak, C. M., Childs, L. M., Grad, Y. H. &Buckee, C. O. Comparing nonpharmaceutical interventions for containing emerging epidemics.Proc Natl Acad Sci U S A. 2017; 114(15): 4023–4028.
13. Wang H.Phase-adjusted estimation of the number of Coronavirus Disease 2019 cases in Wuhan, China. [Cited 18 avr 2020]. Available on: https://www.nature.com/articles/s41421-020-0148-0#ref-CR9
14. Rocklöv J, Sjödin H, Wilder-Smith J. Outbreak on the Diamond Princess cruise ship: estimating the epidemic potential and effectiveness of public health countermeasures. J Travel Med. 2020.[Cited 18 avr 2020].Availableon :https://academic.oup.com/jtm/article/27/3/taaa030/5766334
15. Ceylan Z. Estimation of COVID-19 prevalence in Italy, Spain, and France.Sci Total Environ. 2020;729(10):138817
16. Centre d'études stratégiques de l'Afrique. Cartographie des facteurs de risque de propagation du COVID-19 en Afrique.[Cited 18 avr 2020].Available on:https://africacenter.org/fr/spotlight/cartographie-des-facteurs-de-risque-de-propagation-du-covid-19-en-afrique/#initial
17. World HealthOrganization. [Cited 18 avr 2020]. Available from :https://www.who.int/fr/emergencies/diseases/novel-coronavirus2019/advice-for-public/q-a-coronaviruses
18. Choi K.W., Chau T.N., Tsang O., Tso E., Chiu M.C., Tong W.L., et al. Outcomes and prognosticfactorsin 267 patients withsevere acute respiratory syndrome in Hong Kong Ann Intern Med. 2003;139(9):715-23.
19. Hong K.H., Choi J.P., Hong S.H., Lee J., Kwon J.S,. Kim S.M, et al.WorldHealthOrganization. Statement on the Second Meeting of the International HealthRegulations (2005) Emergency CommitteeRegarding the Outbreak of Novel Coronavirus (2019-nCoV).[Cited 18 avr 2020]. Available on:
https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov).
20. Zhou F., Yu T., Du R., Fan G., Liu Y., Liu Z., et al. Clinical course and riskfactors for mortality of adultinpatientswith COVID-19 in Wuhan, China:aretrospectivecohortstudy. [Cited 18 avr 2020]. Available on:https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30566-3/fulltext
21. Chen N, Zhou M, Dong X, Qu J, Gong F, Y. Han, et al. Epidemiological and clinicalcharacteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study.Lancet. 2020;15;395(10223):507-513.
22. Jaillon S., Berthenet K., Garlanda C. Sexual Dimorphism in InnateImmunity. Clin Rev Allergy

Immunol.2019;56(3):308-321.

23. Channappanavar R., Fett C., Mack M., TenEyck P.P., Meyerholz D.K., Perlman S. Sex-BasedDifferences in Susceptibility to Severe Acute Respiratory Syndrome Coronavirus J Immunol. 2017; 198(10): 4046–4053.
24. Imai N, Cori A, Dorigatti I, Baguelin M, Donnelly CA, Riley S, et al. Report 3: Transmissibility of 2019-nCoV. 2020;6.
25. Read, J. M., Bridgen, J. R. E., Cummings, D. A. T., Ho, A. & Jewell, C. P. Novel coronavirus 2019-nCoV: early estimation of epidemiologicalparameters and epidemicpredictions. [Cited 18 avr 2020]. Available on: https://www.medrxiv.org/content/10.1101/2020.01.23.20018549v1.full.pdf (2020).
26. Ministry of Health of Morocco. [Cited 18 avr 2020]. Available on: https://www.sante.gov.ma/Pages/Communiques.aspx?IDCom=0
27. Weber SM, Levitz SM. Chloroquine interferes with lipopolysaccharide-induced TNF-alpha gene expression by a nonlysosomotropic mechanism. J Immunol 2000;165(3):1534-40
28. Wang LF, Lin YS, Huang NC, Yu CY, Tsai WL, Chen JJ, et al. Hydroxychloroquine-inhibited dengue virus is associated with host defense machinery. J Interferon Cytokine Res 2015;35(3):143-56.
29. World HealthOrganization. Statement on the Second Meeting of the International HealthRegulations (2005) Emergency CommitteeRegarding the Outbreak of Novel Coronavirus (2019-nCoV).[Cited 18 avr 2020]. Availableon:https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov).