WORKING PAPER

The SARS-CoV-2 Pandemic Management:

The Case of Morocco

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Abstract

The resilience of States is put to a severe test in times of major crises, particularly in the face of a pandemic which places a drastic strain on economic activities, disrupts the lifestyles of citizens, weakens social systems and puts pressure on sanitation structures. What is, therefore, the best approach to adopt in such a scenario?

In the first part of this paper, we attempt to underline the epidemiological fundamentals of SARS-CoV-2 before proposing a model to be applied to the Moroccan case that outlines the spread of COVID-19.

In the second part, the paper tackles the additional contribution of technology to curb the pandemic. Several approaches are emphasised, e.g. contact tracing with the aim of protecting the population on a voluntary basis, whilst guaranteeing relative or complete anonymity.

This naturally leads us to the third part of the paper where we deal with social acceptability, the ratchet effect, and ethics as the underlying conditions for the use of personal data.

In short, the structured nature of this article offers original thinking on the capability of coping with the SARS-CoV-2 pandemic under a multi-disciplinary prism able to solve any given problem in its entirety, regardless of its complexity.

Keywords: SARS-CoV-2, SIR Model, Contact Tracing, Ethics, Ratchet Effect

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Introduction

States are both the "depositary of sovereignty, (the) instrument of political power (and the) spokesperson for the general interest" [1]. In this framework, the traditional missions of States consist of:

- Enacting the rule of law;
- Guaranteeing public safety and order;
- Serving justice;
- Defining defence policy, preparing and conducting military operations;
- Defining and conducting the country's foreign policy.

Beyond these "sovereignty responsibilities" [1] and in addition to its operations and/or regulation missions, States "must implement a choice of society (…) and they are accountable for the well-being of their populations and the dissemination of progress in its various aspects" [2].

In other words, [3] defines three main functions of a State:

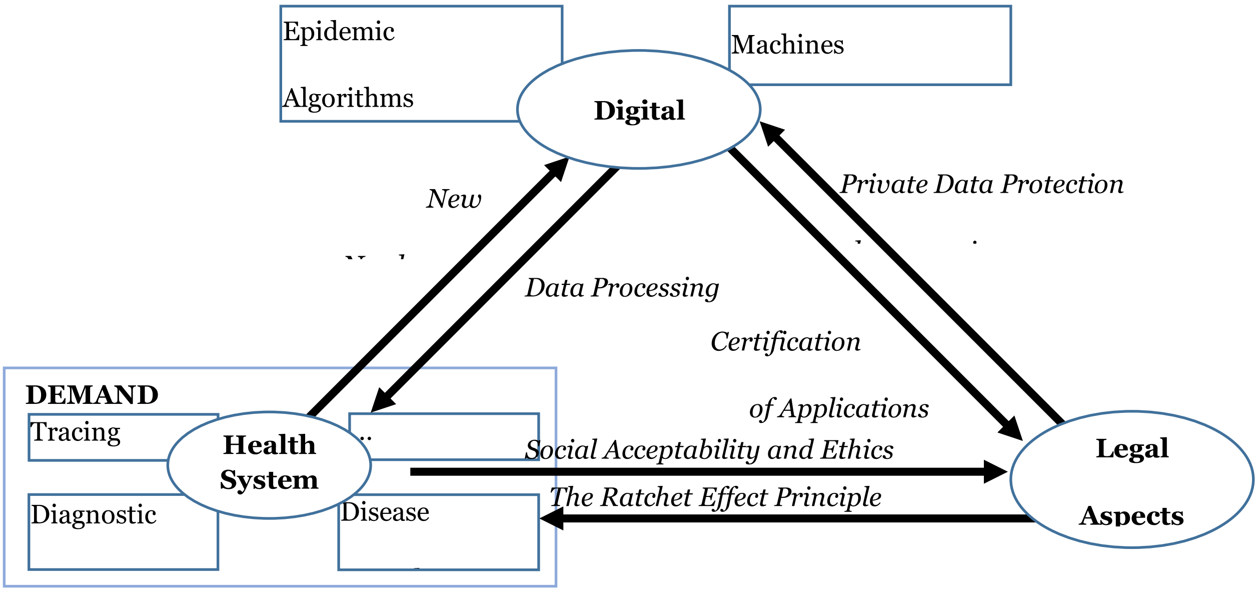
- Resource allocation function;
- Redistribution function;
- Regulation function.

In times of major crisis, such as the COVID-19 pandemic of 2019-2020, States are led to focus more on the functions of resource allocation and redistribution in order to deal with the essentials, particularly in terms of social justice and services that are key to daily life and community, which are all part of the "survival unit" concept [4]. Such a concept alludes to a particular form of entity ensuring security and taking care of basic needs such as food and housing. States become both war chiefs and intensive care structures relegating the macroeconomic equilibrium as a non-priority, in order to devote themselves to the fight against the propagating disease and the imminent threat of death. In this framework, "*Exceptional circumstances call for exceptional actions*"[5]; what are these exceptional measures and actions carried for the sake of survival by States? Such measures are intended to prevent further harsh economic consequences being borne by societies across the World and to save the lives of millions of individuals threatened by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) pandemic.

n this paper (figure [1]), we propose a brief analysis of the epidemiological generalities with some salient measures before modelling the spread of SARS-CoV-2, particularly in Morocco. In the second part, we will look at the contribution of digital technologies to monitoring and fighting epidemics and pandemics, before linking those solutions with social acceptability and aspects of ethics, emphasising the fundamental role of the ratchet effect [5].

[5] Anscombe T. *Public health vs. personal privacy: Choose only one? We live security by ESET.* https://www.welivesecurity.com/2020/03/25/public-health-personal-privacy-choose-only-one/, consulted on March 25, 2020.

Figure 1: A systems perspective



1. The COVID-19 Pandemic

1.1. A Review

The coronaviruses are viruses belonging to the sub-family Orthocoronavirinae and the Coronaviridae family, which have the capacity to mutate and make recombination. CoVs are enveloped viruses with a positive sense, single-stranded Ribonucleic acid (RNA) genome (group IV of the Baltimore classification) [6]. With genome sizes ranging from 26 to 32 kilobases (kb) in length, CoVs have the largest genomes for RNA viruses.

Bats and birds are excellent hosts for coronaviruses, representing a reservoir of evolution and dissemination. Following mutations, coronaviruses can change hosts and human-to-human transmission occurs mainly through close contact via respiratory droplets generated by sneezing and/or coughing [7], [8].

The emergence of types of coronavirus that can cause severe lung disease marked a new era in the interspecies transmission of severe respiratory disease [9], [10]. Previous coronavirus epidemics (CoVs) include SARS-CoV, a pathogen of severe acute respiratory syndrome (SARS) in 2002-2004; MERS-CoV, the Middle East respiratory syndrome in 2012; and, most recently, SARS-CoV-2, the causal agent of the 2019 coronavirus disease (COVID-19), which appeared in China in December 2019 and caused a severe pandemic in 2020.

The timeline for COVID-19 infections is shown in the table [1]. The first cases were reported in December 2019 and, by January 2, 2020, 41 hospital patients had been identified as having laboratory-confirmed COVID-19 infection. Less than half of these patients had underlying illnesses, including diabetes, hypertension, and cardiovascular disease [11], [12]. On January 22, 2020, a total of 571 cases of the new 2019 coronavirus (COVID-19) had been reported in 25 provinces (districts and cities) in China [13]. The Chinese National Health Commission didn't release details of the first 17 deaths until January 22, 2020. On January 25, 2020, a total of 1,975 cases were confirmed of those infected with COVID-19 in mainland China, with a total of 56 deaths [14].

The first case of the COVID-19 infection confirmed at the Institut Pasteur-Morocco laboratory by the Moroccan Ministry of Health was on March 2, 2020. He was a Moroccan national residing in Italy. Positive testing has led to description, identification, diagnosis, clinical course, and management of this case.

In addition, the first case of human-to-human transmission of COVID-19 was reported in Morocco on March 5, 2020.

Table 1: Timeline of the main SARS-CoV-2 events

12/31/2019	China reports a cluster pneumonia in Wuhan.
01/01/2020	The World Health Organization (WHO) established an Incident Management Support Team (IMST).
01/04/2020	WHO reports cluster of pneumonia cases - no deaths - in Wuhan.
01/05/2020	WHO publishes first bulletin on outbreaks.
01/12/2020	The genetic sequence of the COVID-19 virus is published by China.
01/13/2020	Thailand reports a first case of COVID-19; the first case outside China.
01/14/2020	WHO (Dr. Maria Van Kerkhove) indicates there is a risk of a large scale epidemic.
01/22/2020 & 01/23/2020	WHO organises a meeting to determine if the outbreak is a Public Health Emergency of International Concern (PHEIC). No consensus based on the data available at the time.
01/30/2020	Consensus considering that the outbreak of new coronavirus constitutes a Public Health Emergency of International Concern.
03/03/2020	WHO: Strategic plan for preparedness and response of the international community to help protect States where healthcare systems are fragile.
03/11/2020	WHO believes COVID-19 can be described as a pandemic.
03/18/2020	"Solidarity", an international clinical trial which aims to generate solid data from around the World to find the most effective treatments for COVID-19.

1.1.1. *Symptoms and Diagnosis*

The most common symptoms at the onset of the COVID-19 disease are fever (about 39.0°C), cough, and fatigue, whilst other symptoms include sputum production, headache, hemoptysis, diarrhoea, dyspnea, and lymphopenia. Individuals infected with COVID-19 displayed higher white blood cell counts, respiratory abnormalities, and increased levels of pro-inflammatory plasma cytokines. The diagnosis of people with symptomatic signs has shown positive real-time polymerase chain reaction results, which have confirmed COVID-19 infection [15]. For severe cases, high levels of pro-inflammatory cytokines, promoting the severity of the disease have been shown [12].

1.1.2. Measures

Several treatments, which could reduce or control the viral infection (oseltamivir, lopinavir, ritonavir, intravenous ganciclovir, remdesivir, hydroxychloroquine and azithromicyn combination), have been administered for people infected with the SARS-CoV-2. Nevertheless, it should be noted that, at the date of publication of this paper, there is no specific antiviral drug or vaccine against the COVID-19 infection that provides an effective therapy in humans.

In fact, in order to control the current epidemic, several measures, including diagnosis, confinement, treatments and other additional solutions such as the smart use of technologies, must be put in place to reduce the transmission of COVID-19 from person to person. Besides this, special attention must be paid to some categories of people, in particular children, health care providers and old people.

Nevertheless, several questions remain unresolved, including epidemiological changes, adaptation and evolution of human-to-human virus transmission.

Quantified studies must be carried out on the number of people who have been tested, in order to determine the positively tested proportion. Other questions ought to be addressed such as: whether this proportion remains stable or variable; how many of them have developed a serious disease; how many have shown no clinical sign; and, finally, why very few pediatric cases get the virus?

In addition to this questioning, it would be necessary, as a first step, to try to understand the spread of the virus.

1.2. The Revisited SIR Model

Morocco, as well as the Rest of the World, needs to understand the evolution and propagation of the COVID-19 disease on its territory.

How can we, therefore, model the spread of the COVID-19 disease, in order to be able to propose valuable measures that will enable the slowdown of the pandemic?

1.2.1. *Capturing the Course of the SARS-CoV-2 Pandemic in Morocco*

The literature is rich as far as mathematical models applied to infectious diseases [16], [17], [18]. Amongst these models, there are two categories, namely the stochastic models and the deterministic ones, also called the “compartmental models in epidemiology”. In the case of pandemics impacting large populations, it is the latter category of models that is preferred, accompanied by carrying out sensitivity analysis..

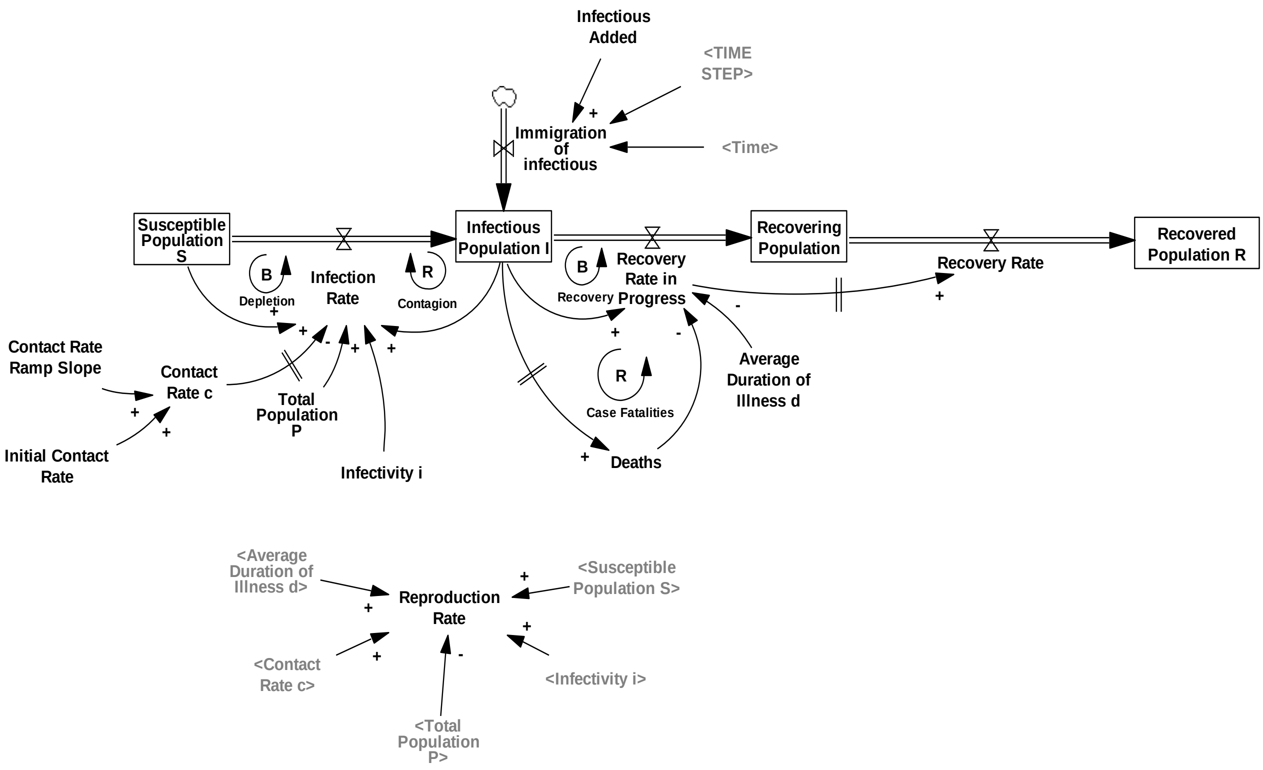
Two major types of modelling fall into this category:

- The Susceptible - Infectious - Recovered (SIR) model;
- The Susceptible - Infectious - Susceptible (SIS) model, more suited to the seasonal infections (common cold and influenza).

In our particular case, taking into account the epidemiological characteristics of the SARS-CoV-2, we will build a model to capture the course of the epidemic in Morocco, divided into four stocks: those susceptible to the COVID-19 disease, S; those who are infectious, I; the recovering population, and the recovered one, R, thus adapting the Kermack-McKendrick formulation [19] widely used in epidemiology.

Schematically, this revisited SIR model, developed within the framework of the system dynamics approach [20], contains four major loops: a reinforcing contagion loop, a balancing depletion one, a reinforcing case fatalities loop, and a balancing recovery loop (figure [2]).

Figure 2: Structure of the SIR epidemic model (adapted from Repenning 2011[6])



[6] Repenning N. Understanding Epidemics Using VensimPLE, *MIT Sloan School of Management* 2011.

As seen in the figure [2], the model has exogeneous inputs (contact rate ramp slope, initial contact rate, infectivity I, total population P, average duration of illness d) and endogeneous variables (infection rate, deaths, contact rate c, recovery rate in progress, recovery rate).

In the excerpt below, are some descriptions of the main variables of the model (table [2]):

Table 2: Some variables of the SIR Revisited SIR Model

Contact Rate c = Initial Contact Rate*ramp(Contact Rate Ramp Slope,10,20) Units: 1/Day People in the community interact at a certain rate (the Contact Rate, c, measured in people contacted per person per time period, or 1/time periods). The contact rate rises at the Ramp Slope starting in day 1.
Contact Rate Ramp Slope = 0.5 (for the hypothetical Moroccan scenario with a delayed policy of confinement) / **0.1 (for the Moroccan scenario)** Units: 1/Day The rate at which the contact rate rises.
Infectivity I = 0.1527 Units: Dimensionless The infectivity (i) of the disease is the probability that a person will become infected after exposure to someone with the disease.
Infection Rate = DELAY1I(Contact Rate c,4,Contact Rate c)*Infectivity i*Susceptible Population S*Infectious Population I/Total Population P Units: People/Day With a certain delay of 4 days, the infection rate is the total number of encounters S multiplied by the probability that any of those encounters is with an infectious individual I/P, and finally multiplied by the probability that an encounter with an infectious person results in infection i.
Total Population P = 10000 Units: People The total population is stated as constant. 10000 is only a calculation value. It could be changed within the model or following a sensitivity analysis.
Average Duration of Illness d = 14 Units: Day

The average length of time that a person is infectious. The 14 days value can be changed within a sensitivity analysis.
Deaths = DELAY1I(0.074*Infectious Population I,15,0.074*Infectious Population I) Units: People With a certain delay of 15 days, some infectious individuals could die as a proportion of 7.4%, as observed in Morocco until the first half of April 2020. This proportion is variable and could be changed within a sensitivity analysis, accompanied by new simulations.
Recovery Rate = DELAY FIXED(Recovery Rate in Progress,12,Recovery Rate in Progress) Units: People/Day With a delay, the rate at which the infected population recovers and becomes immune to the infection.

For further information, the Appendix shows in detail the different mathematical equations used in the model, as well as the parameter values retained.

The "stock and flow" structure shows that the susceptible population is reduced by the "infection rate" while the "infectious population" accumulates the "infection rate" less the "recovery rate in progress" and the "deaths".

The "recovered population" takes into account the "recovery rate" defined as the "infectious population" divided by the "average duration of illness" with the assumption that removals are high-order, meaning that the delay between infection and removal is not compulsorily exponential.

The imported infections case was also dealt with via the "Immigration of infectious" variable that stipulates an entry of contaminated people on Moroccan territory during a short period of 18 days, between the appearance time of the "patient 0" and the instant of the complete closure of the country's land, air and sea borders.

1.2.2. *Results and Discussions*

Based on the Euler integration method, the figure [3] shows a 90-day Monte Carlo simulation of the model, where the system has passed the point of inflexion. The population of the simulated community is 10,000 and, initially, everyone is susceptible to the disease. Following the assumptions as of April 11, 2020, the average duration of illness is 14 days and infectivity is 15.27%[7] according to the most significant global data, based on the countries that administered the highest number of diagnostic tests. Morocco reports an infectivity value of around 24% (as of April 11, 2020), but with an

[7] Roser M, Ritchie H, Ortiz-Ospina, E. Coronavirus Disease (COVID-19) – Statistics and Research. *Published online at OurWorldInData.org*. Retrieved from: 'https://ourworldindata.org/coronavirus'[Online Resource consulted on April 11, 2020].

extremely targeted and non-generalised administration of the diagnostic tests on the drafting date of this paper. In addition, the case fatality rate in Morocco is around 7%8 (as of April 11, 2020) against an estimated world average of 6%9.

Moreover, **Morocco quickly implemented a series of measures aimed at protecting its population, including a clear and generalised policy of confinement**.

In this framework, we can valuably adopt for Morocco a mean contact rate ramp slope equal to 10% at the origin, taking into account some misconduct of the population, whilst in comparison, some countries report a late policy in terms of confinement, conducting to a mean contact rate ramp slope beyond 50% (approximately 26.5 degrees) at the origin.

The figure [3] clearly illustrates the **relevance of the strategy adopted by Morocco** through the establishment of an accelerated confinement policy. In this case, we can easily compare the peaks of infection in each of the two developed scenarios..

Note that a sensitivity analysis was performed by changing the values of the main exogenous data one by one (figure [4]).

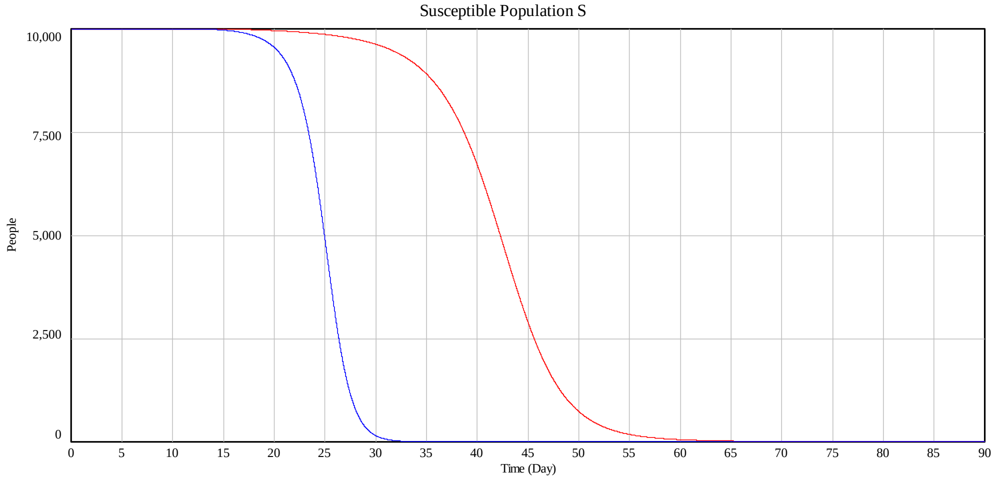
Therefore, the positive contagion loop dominates and the epidemic quickly spreads. The infection rate peaks at slightly more than 805 people per day around the 42nd day and at its peak, around the 48th day, the infectious population reaches more than 5 450 people.

After a plateau, the susceptible population falls rapidly and it is this depletion of potential new cases that slackens the epidemic. In addition, it is estimated in the Moroccan case that, 90 days after the appearance of "patient 0", the population likely to contract the coronavirus would be reduced to nothing.

8Ministère de la Santé. Le Portail Officiel du Coronavirus au Maroc. http://www.covidmaroc.ma, consulted on April 11, 2020.

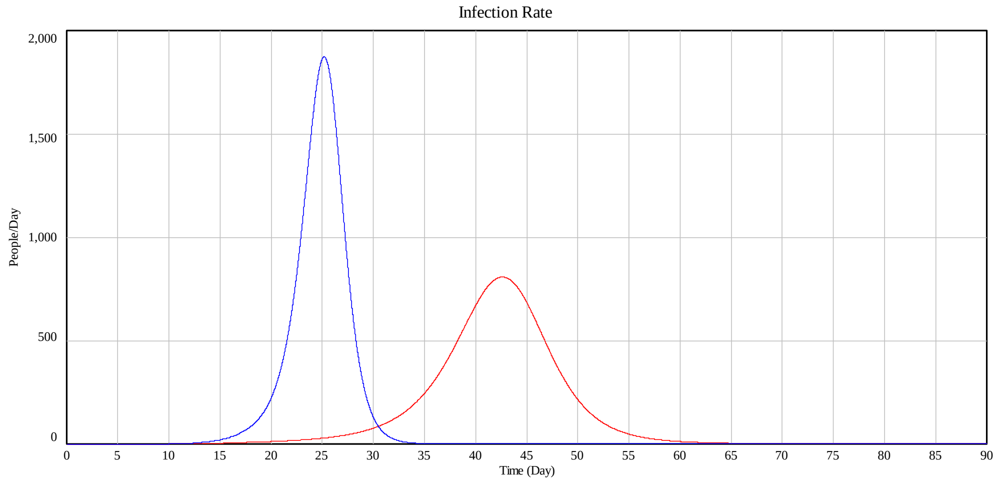
9 Roser M, Ritchie H, Ortiz-Ospina E. *Ibid*.

Figure 3: Simulation of the SARS-CoV-2 epidemic in the revisited SIR model



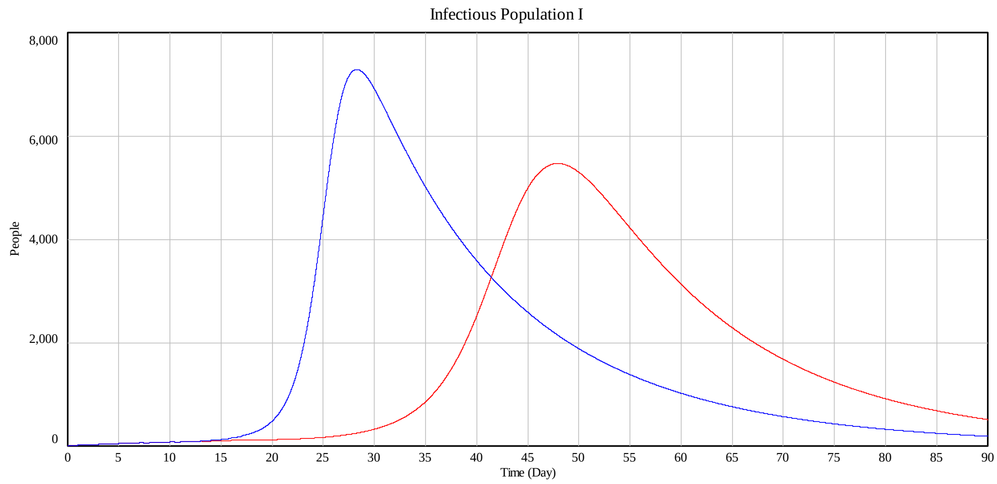
Red curve: *Moroccan scenario (contact rate ramp slope equal = 10%)*

Blue curve: *Hypothetical Moroccan scenario with a delayed policy of confinement (contact rate ramp slope = 50%*



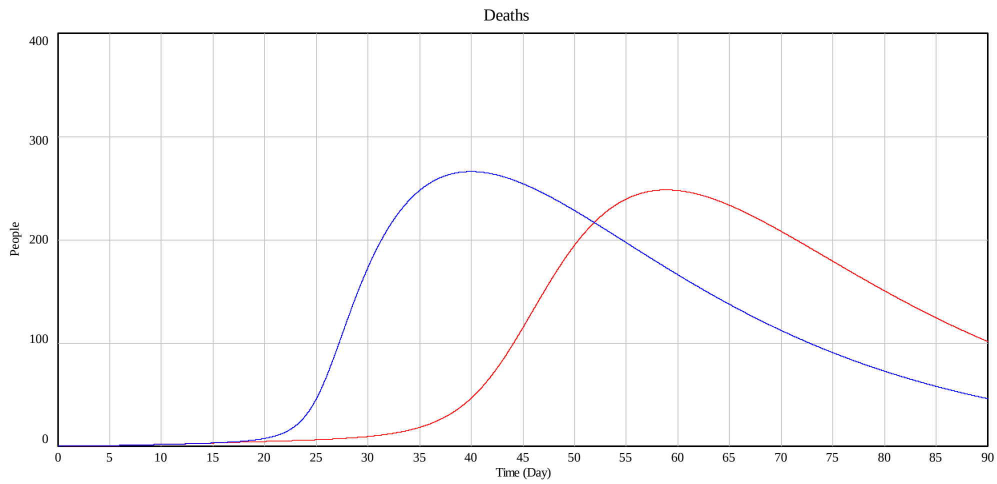
Red curve: *Moroccan scenario (contact rate ramp slope equal = 10%)*

Blue curve: *Hypothetical Moroccan scenario with a delayed policy of confinement (contact rate ramp slope = 50%*



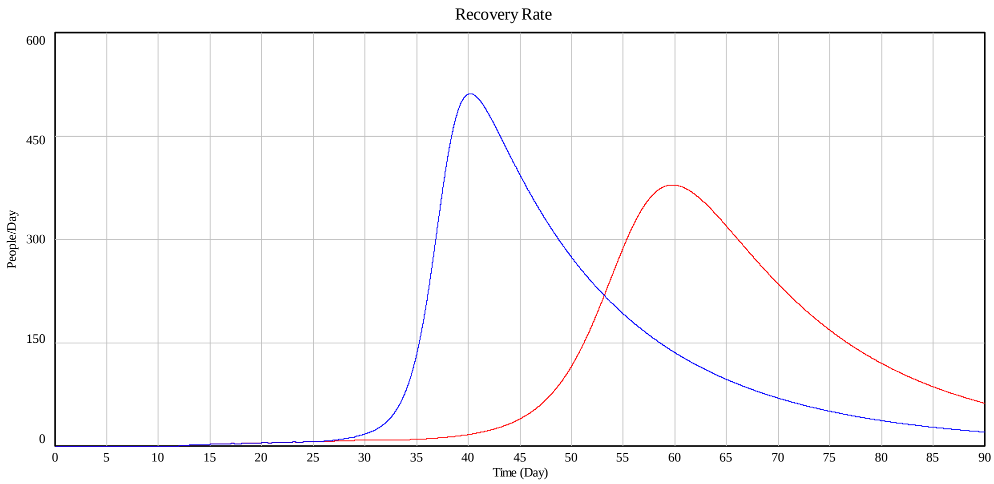
Red curve: *Moroccan scenario (contact rate ramp slope equal = 10%)*

Blue curve: *Hypothetical Moroccan scenario with a delayed policy of confinement (contact rate ramp slope = 50%*



Red curve: *Moroccan scenario (contact rate ramp slope equal = 10%)*

Blue curve: *Hypothetical Moroccan scenario with a delayed policy of confinement (contact rate ramp slope = 50%*



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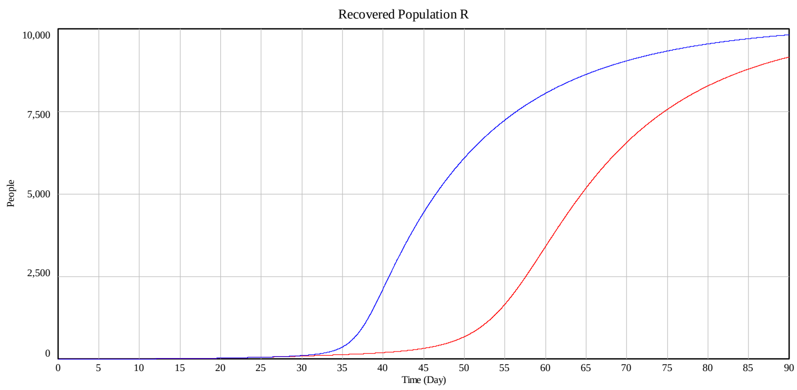
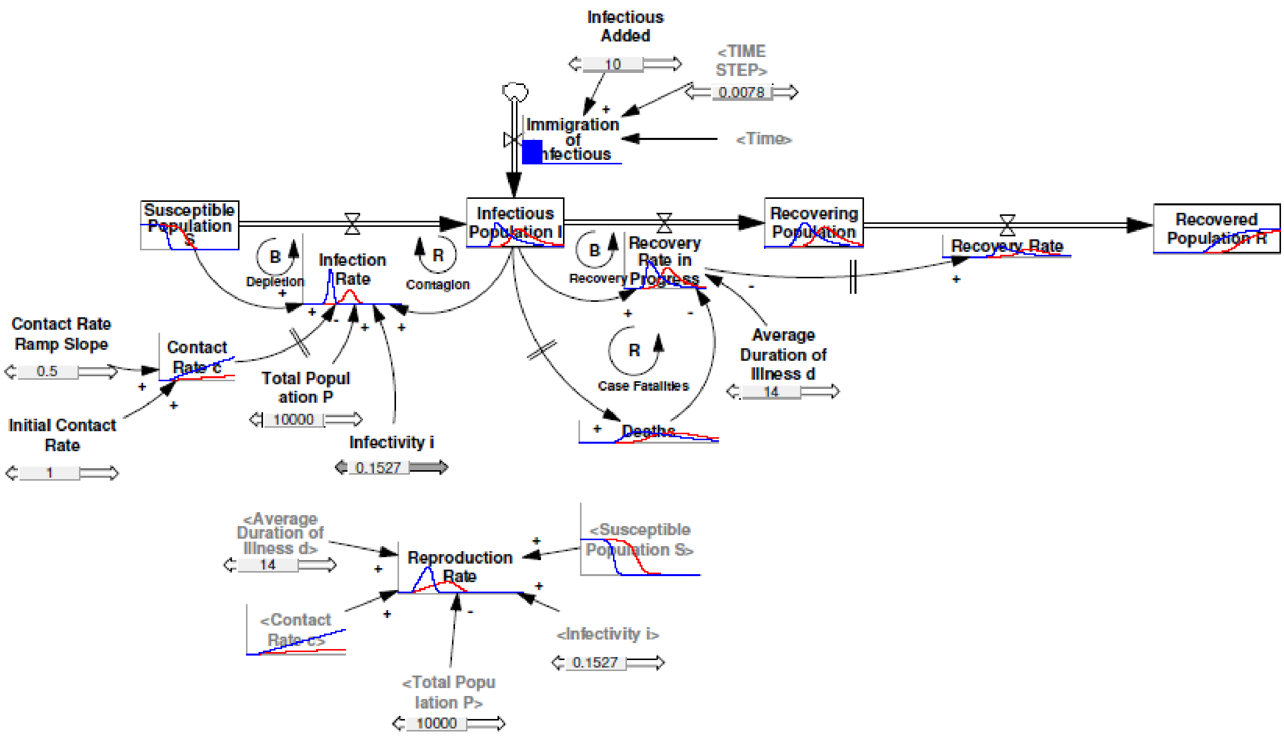


***Red curve**: Moroccan scenario (contact rate ramp slope equal = 10%)*

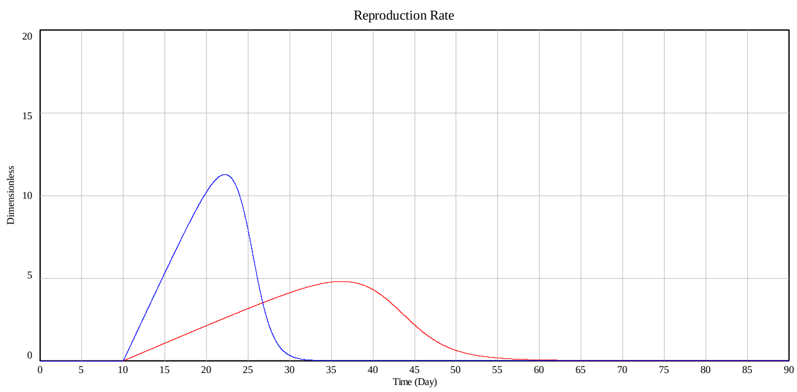
***Blue curve**: Hypothetical Moroccan scenario with a delayed policy of confinement (contact rate ramp slope = 50%*

Figure 4: Sensitivity analysis on the exogeneous parameters of the revisited SIR model



In addition, the tipping point at which the coronavirus epidemic occurs was estimated during the 14th day after the "patient 0" appearance. The figure [5] plots the reproduction rate - generally denoted R0 and defined through the expression cid*(S/P) - graph for the epidemic.

Figure 5: Reproduction rate of the SARS-CoV-2 and its tipping point



Red curve: *Moroccan scenario (contact rate ramp slope equal = 10%)*

Blue curve: *Hypothetical Moroccan scenario with a delayed policy of confinement (contact rate ramp slope = 50%)*

In short, whilst we have assumed a homogeneous population, a more advanced version of this model could segment the "susceptibles" to SARS-CoV-2 (people prone to infections by SARS-CoV-2) on the basis of an intelligent processing of the available massive health data, using the techniques of artificial intelligence. The clustering process could lead to an OS - Overall Similarities - type segmentation [21], [22] that finely distinguishes several categories of population according to various variables (age group, state of health, body shapes, variable infectivity according to the different characteristics of human groups).

2. Complementary Role of Digital in the SARS-CoV-2 Pandemic Management

2.1.Definition of Contact Tracing

Contact tracing (or proximity tracing) refers to containing a disease by identifying, following-up and subsequently quarantining everyone that the infected person has been in close contact with and who might, potentially, be carriers of the viruses (positive testing). It is a common tool increasingly deployed by public health workers.

Technically, an application already installed on a mobile phone, creates/establishes a connection of data and registers the user with that data. It also records close proximity between people, data collected through Bluetooth, WiFi, or GPS.

When a user is diagnosed positive, the application notifies people that have been in prior contact to self-isolate and warns local health authorities. Contact tracing can be defined as "a problem of secure communication between pairs of users who come into contact in the physical world" [23].

It relies on different parameters that must be tuned in, depending on epidemiological modelling. To be clearer, the concept of the "the exposure time" can be used. Such a notion might be defined, according to some studies, as face-to-face contact for more than 15 minutes whilst, for others, contact established for less than 15 minutes could be considered as a significant exposure time. There is no clear consensus on some parameter values and as research is evolving, researchers acquire better modelling.

Recently, contact tracing appears to be a promising solution to slowing down the spread of the SARS-CoV-2. Some governments, like the United Kingdom [24], the United States of America [25], Germany [26], and Israel [27], have already started developing technology based on contact tracing to predict the geographic spread of the virus, as well as to determine the effectiveness of security measures, such as confinement. To respond to this increasing demand, developers show a huge interest for contact tracing and big players such as Google and Apple decided to join, in order to lay out a new protocol for tracking the virus. Their ongoing project consists of an automated contact tracing system that can operate at a larger scale than conventional contact tracing, providing more effective tracking over the country and, most importantly, potential availability for Android and iPhone holders (representing more than three billion mobile phones around the world).

Contact tracing does not only provide citizens with the information they need to minimise the risk of being contaminated by the virus, but it also helps governments to control the spread of the disease, by knowing who leaves the location of the confinement and allowing them to take appropriate actions in case of a continued breach of rules. This last point might be controversial, since it can be interpreted as involuntary tracing.

2.2. Learn from Experiences

As part of the Ebola epidemic response, a contact tracing application, named CommCare [28], was developed in Guinea. It allowed a real-time identification of contacts who have not been visited, through time stamps and collection of GPS points. CommCare was first deployed in Conakry, in November 2014. It then expanded to a total of five prefectures by April 2015, monitoring 9162 contacts.

With the propagation of the SARS-CoV-2, multiple countries have considered the role that can be played by technology.

In China as well and since February 2020, an application has been used to send an orange or red code if a citizen is suspected of carrying the virus and then they must self-isolate.

On March 20th 2020, Singapore used contact tracing to control the COVID-19 pandemic, via an application called TraceTogether App. This later records people you encounter and the "contact duration", using short-distance Bluetooth signals and stores this data for 21 days. However, due to privacy concerns, this application does not record location data or access the user's phone contact list or photos. In addition, data is stored in an encrypted form using "cryptographically generated temporary IDs".

Israel developed an application, called "The Shield", that informs users if they have crossed paths with someone known to have been infected with the SARS-CoV-2. Since the Health Ministry is publishing the whereabouts of people diagnosed with COVID-19, the application simply compares this information with location data collected from the user's phone. Note, that the Ministry servers continue storing the data regarding the location histories of confirmed cases during the 14 days following their diagnosis.

France, similarly, is also actively developing a contact tracing application "StopCovid" that uses location tracking to send alerts to people who have been in contact with an infected person to self-isolate. This application uses Bluetooth to detect proximity and it is meant to be on a voluntary basis.

2.3. Contact Tracing Issues

Whilst potentially very effective, contact tracing also enables the collection of an extremely large amount of sensitive data. Thus, strong technical solutions are needed, as well as transparent ones, because the lack of regulatory oversight can affect the confidence of citizens in the government.

Clearly, contact tracing poses **ethical constraints**. Actual security concerns regarding the use of contact tracing include, but are not only limited to:

- Limiting personal data gathered by governments;
- Protecting anonymity of users (specially infected and at-risk people);
- Protecting users from malicious external attacks;
- Ensuring that the system "does what it claims".

The answer to these concerns relies on thoughtful design and clear implementation.

In summary, regardless of ethical and security concerns, contact tracing appears to be a suitable solution to achieve pandemic control, by only targeting people at risk and restricting social distancing to high risk geographic areas, thus, allowing economies to re-start.

3. Digital Solutions and Social Acceptability for a Wise Management of the SARS-CoV-2 Pandemic

Fundamental principles at the heart of our societies are being put to the test by the current crisis. Liberty and the sacredness of our privacy as citizens could be threatened by multiple measures deemed necessary for managing the unfolding crisis. "Contact tracing" is identified in this article as an illustration of such potentially threatening measures.

As claimed by Brandeis10, "recent inventions and business methods call attention to the next step which must be taken for the protection of the person, and for securing to the individual … the right 'to be let alone' … Numerous mechanical devices threaten to make good the prediction that 'what is whispered in the closet shall be proclaimed from the house-tops."

It is of utmost importance to seek a sort of equilibrium between, on the one hand, the implementation of urgent measures to tackle the present crisis and, on the other hand, the preservation of key societal values guaranteeing peace, cohesion and stability.

[10] It is to be noted here that Brandeis and Warren published "The Right to Privacy" in the Harvard Law Review in 1890. It is the first major article advocating a legal right to privacy.

Warren SD, Brandeis LD. The Right to Privacy. Harvard Law Review 1890; 193-220.

3.1.Regulation

The role to be played by Law and institutions cannot be ignored and must be questioned. Thus, the issue of a legal framework to safeguard the aforementioned principles is to be raised.

In Morocco, multiple instruments could be pinpointed as fundamental for the protection of individual privacy and personal data.

3.1.1. The Moroccan Legal Framework for Personal Data Protection

Since May 2019, Morocco became the 55th nation to join the Convention 108, known as the Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data. Morocco is also the sixth country in the African Region to join the Convention 108. Besides this, the ratification instruments to the Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data - European Treaty Series (ETS) 108 - and to its additional Protocol regarding supervisory authorities and trans-border data flows (ETS 181) were deposited. It is to be underlined that the Convention and the additional Protocol entered into force on September 1st, 2019.

At the level of the **Moroccan Constitution**, we must mention Article 24 that affirms: "All individuals have the right to the protection of their private lives".[11]

Also, we must refer to **Law n°09-08** "relative to the protection of physical persons in relation to processing of personal data" (published in the Bulletin Officiel n°5714 of March 5th 2009). Besides this, we must also cite the Decree n°2-09-165 for application of Law n°09-08 (published in the Bulletin Officiel n°5744 of June 18, 2009). It is to be underlined that the **Law n°09-08** has been enacted in the framework of the Maroc Numeric 2013 Strategy. The first article of the aforementioned Law (Law n°09-08) affirms that "Data processing is at the service of the citizen and evolves in the framework of international cooperation. It should not threaten the collective identity, rights and liberties of Men. Also, it should not constitute a means to divulgate secrets of the private lives of citizens".

It must be pointed out that Law n°09-08 does not apply to "nominative data" which has been made anonymous, except if it is rendered identifiable [29].

Last but not least, amongst notable legal instruments to be pointed out, is the **Decision n°3-33-11** approving the "Internal Rules and Regulations" of the National

[11] Article 24 of the Moroccan Constitution affirms that « *Any person has the right to the protection of their private life. The domicile is inviolable. Searches may only intervene in the conditions and the forms provided by the law. Private communications, under whatever form that may be, are secret. Only justice can authorize, under the conditions and following the forms provided by the law, the access to their content, their total or partial divulgation or their summons [invocation] at the demand [charge] of whosoever.* ».

Commission for Control of the Protection of Personal Data (CNDP), published in the Bulletin Officiel of April 7, 2011.

3.1.2. The Moroccan Data Protection Authority

The main mission of The Moroccan Data Protection Authority (CNDP) is to ensure the respect of the liberties and rights of individuals in relation to personal data processing.

The institution was entrusted to conduct transversal missions within five major fields of action: (1) Information and sensitisation; (2) Consulting and "proactiveness"; (3) Protection; (4) Control and investigation, and (4) Legal and technological monitoring.

It is to be underlined that Morocco, through the CNDP, is an accredited member of the International Conference of Data Protection Authorities, The Association of Francophone Data Protection Authorities, and the Global Privacy Enforcement Network of the Organisation for Economic Co-operation and Development (OECD). Moreover, it must be noted that the CNDP has been active alongside the European programme for Improving Practical and Helpful Cooperation between Data Protection Authorities (PHEDRA).

The existence of a potentially effective legal framework and instruments accompanied by the CNDP, as an institution entrusted to ensure control and monitoring of the protection of personal data, are valuable assets to be mobilised during the current period Morocco is undergoing, as a consequence of this global crisis.

3.1.3. The State of Sanitary Emergency

On the legal basis of Article 81 of the Moroccan Constitution of 2011[12] and in the framework of the various preventive measures taken by the public authorities in order to limit the propagation of the SARS-CoV-2, the Moroccan government adopted on March 22, 2020 the Decree Law n°2.20.292 edicting specific measures to the State of Sanitary Emergency (published in the Bulletin Officiel n°6867 of March 24th, 2020). Article 5 of the aforementioned Decree Law, affirms that "the government can take in the case of absolute necessity exceptional economic, financial, social or environmental measures that can contribute to facing the negative impact of the declared State of Sanitary Emergency".

Thus, public authorities retain the responsibility of decision-making with regards to such a question, whilst preserving the founding principles lying at the heart

[12] It is to be noted that Article 81 of the Moroccan Constitution allows the government to take in the interval of parliamentary sessions and with the agreement of the concerned commission of the two Houses of Parliament decree-laws, which are to be submitted to ratification by the Parliament in the next ordinary session.

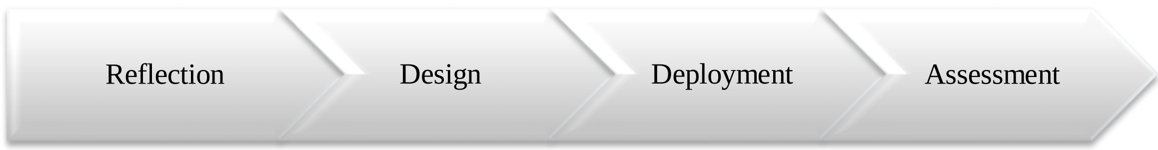
of our societal cohesion. States must delve into an ethical path consecrated by reinforced legal guarantees.

Besides this, the role and prerogatives of the national monitoring agency, CNDP, could be reinforced in such exceptional circumstances.

Contact tracing as a measure for facing up to the SARS-CoV- 2 entails addressing ethical considerations and legitimate fears, in order to preserve the rule of law.

In the context of an exceptional sanitary crisis, the government could extend its action as far as data processing in the new regime implemented by the Decree Law n°2.20.292. Throughout the process of reflection, design, deployment, and assessment of such preventive measures (figure [6]), key principles ought to be respected including data protection by default and data protection by design. Data protection by design refers to “the use of pseudonymisation (replacing personally identifiable material with artificial identifiers) and encryption (encoding messages so only those authorised can read them)”. As for data protection by default, it refers to the encouragement of social media platforms to set “users’ profile settings in the most privacy-friendly setting by, for example, limiting from the start the accessibility of the users’ profile so that it isn’t accessible by default to an indefinite number of persons”.[13]

Figure 6: Towards the implementation of “intelligent technological solutions”: From reflection to Assessment



3.1.4. Beyond Morocco: The PEPP-PT Initiative

The Pan-European Privacy Preserving Proximity Tracing (PEPP-PT) is an initiative which brings together a Switzerland-based consortium of researchers in order to develop applications that can support contact tracing efforts within countries and across borders. It is to be noted that the above-mentioned Singapore’s TraceTogether service is being implemented as a model.

[13] The definitions are based on Article 25: Regulation (eu) 2016/679 of the European Parliament and of the Council of April 27, 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

Such an approach is in line with the mission of the PEPP-PT initiative, which is committed to embracing a **fully privacy-preserving approach** to make it possible to interrupt new chains of SARS-CoV-2 transmission rapidly and effectively by informing potentially exposed people. 14

Finally, it must be emphasised that the PEPP-PT is "an international initiative providing technical standards, mechanisms, and services creating interoperability to local implementations".15 It remains to be seen what the perspectives of PEPP-PT will be for implementation beyond European countries.

3.2. Global Risks

Today, more than 28 countries are enacting surveillance measures to combat the SARS-CoV-216. It has to be pointed out that "the most common form of surveillance implemented to battle the pandemic is the use of smartphone location data, which can track population-level movement down to enforcing individual quarantines"17. OneZero has been able to constitute a constantly updated list of "reports of potentially privacy infringing technology" in multiple countries18.

It is to be pointed out that times of crises are accompanied by societal transformations and it remains to be examined whether there could be a return to the status quo ante.

[30] coined the "ratchet phenomenon" applied to the State's role in the context of the 20th Century crises in the United States to define a context of sudden growth of the government with each crisis. For [30], crises "produced not just a temporarily bigger government but also permanently bigger government". The analyses of [30] regarding the ratchet phenomenon portray interesting conclusions as far governmental growth in times of crises, to the extent it confirms our hypotheses in times of crises on the extension of the role to be played by States as territories and spaces of survival for the individuals. During pandemics in particular, States retain the responsibility to protect and save the lives of their populations. Besides this, as units of survival, they are also accountable for the preservation of their rights and liberties, even when they seek advanced technology-based solutions, such as contact-tracing to wage the battle against global invisible threats. These moments are key transitional phases that test States and their populations on their propensity to survive as a

14 The Pan-European Privacy Preserving Proximity Tracing. https://www.pepp-pt.org/, consulted on April 11, 2020.

15 PEPP-PT Context and Mission: https://404a7c52-a26b-421d-a6c6-96c63f2a159a.filesusr.com/ugd/159fc3_878909ad0691448695346b128c6c9302.pdf, consulted on April 11, 2020.

16 One Zero. We Mapped How The Coronavirus Is Driving New Surveillance Programs Around The World. https://onezero.medium.com/the-pandemic-is-a-trojan-horse-for-surveillance-programs-around-the-world-887fa6f12ec9, consulted on April 11, 2020.

17 One Zero, *Ibid.*

18 One Zero, *Ibid.*

cohesive society. Increased risks, such as normalisation of surveillance, should be mitigated. Otherwise, trust, which is at the heart of societal fabric, can be lost.

In that way, the proportionality principle, for instance, must apply to the extent that "the least intrusive solutions should always be preferred, taking into account the specific purpose to be achieved"19.

"Invasive measures" ought to be avoided, to stay aligned with the fundamental values which construct States as survival units, that must preserve civil liberties amid the advent of an exceptional context. It is to be emphasised that such an exceptional context, like the one the world is currently undergoing, is in great need - at State and interstate levels - of "compliance and co-operation" [31]. The latter key ingredients cannot be achieved, as pointed out by Yuval Noah Harari, without trust: "trust in science, trust in public authorities and in the media" [31]. In times of crises, "you suddenly discover a hidden reservoir or trust and amity, and you rush to help one another" [31]. The value of trust in the context of crises cannot be overstated.

It is trust that can allow States to achieve and build together with their populations a desired sustainable well-being. Technology is evidently a key tool which retains the potential to contribute to solving multiple complex equations; nonetheless, it ought to be deployed wisely.

Conclusion and Further Research

In times of major crisis, or even pandemic, such as the 2019-2020 coronavirus episode, the role of States is instantly transformed to deal with the essentials, to support basic services, to help the most vulnerable people, and to try to overcome experienced disturbances in the most appropriate way, whilst hoping to mitigate the strongly negative post-crisis impact.

Fundamentals are thus brought into effect, evolving into the opening of a new era after a very probable world economic recession, indirectly recalling the lessons of Joseph Schumpeter on his theory of "creative destruction".

In fact, with COVID-19, as people have been forced to work from home following the confinement rules, avoid travel, refrain from shopping in retail stores, and stop eating at restaurants, the world economy has been severely rattled. Viewed in this way, the disruptions from the SARS-CoV-2 are on track to continue for months.

Thus, this paper attempts to explain some major epidemiological characteristics, to underline the merits of different measures, and to propose a general tool that can help predict the evolution of the SARS-CoV-2 pandemic. Applied to Morocco over a period of 90 days, this revisited model has emphasised the positive

19 European Data Protection Board. Statement on the processing of personal data in the context of the COVID-19 outbreak.

https://edpb.europa.eu/sites/edpb/files/files/file1/edpb_statement_2020_processingpersonaldataandcovid-19_en.pdf, consulted on March 19, 2020.

impact of the confinement policy adopted by the Moroccan government at the very beginning of the first phase of the epidemic.

In the second part, we discuss the contribution of data and artificial intelligence that is capable of controlling and helping to manage the epidemic through digital solutions based on different techniques; solutions that will enable us to be better equipped to face future health crises of varying magnitude.

In the third part, we question the potential abuses emanating from AI solutions that could undermine certain freedoms and infringe the right to and respect of a private life. The ratchet effect, developed in this paper, perfectly addresses this problem.

Future research should consider the positive impact of artificial intelligence more carefully on the proposed revisited epidemiological model through improved data treatment able, for example, to monitor and predict the spread of any epidemic disease inside multiple homogeneous categories of individuals, thus offering the possibility of implementing less restrictive measures, but which are just as effective as confinement.

Disclosure Statement

No potential conflict of interest is reported by the authors.

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Appendix

(01) Average Duration of Illness d = 14

Units: Day

The average length of time that a person is infectious.

(02) Contact Rate c = Initial Contact Rate*ramp (Contact Rate Ramp Slope,10,20)

Units: 1/Day

People in the community interact at a certain rate (the Contact Rate, c, measured in people contacted per person per time period, or 1/time periods). The contact rate rises at the Ramp Slope starting in day 1.

(03) Contact Rate Ramp Slope = 0.5 (for the hypothetical Moroccan scenario) / **0.1 (for the real Moroccan scenario)**

Units: 1/Day

The rate at which the contact rate rises.

(04) Deaths = DELAY1I(0.074*Infectious Population I,15,0.074*Infectious Population I)

Units: People

(05) FINAL TIME = 90

Units: Day

The final time for the simulation.

(06) Immigration of infectious = IF THEN ELSE (INTEGER (Time/1) = Time/1,Infectious Added/TIME STEP,0)*(1-STEP(1,18))

Units: People/Day

The immigration of the infectious is the rate at which infectious people come into the population for outside of the system.

(07) Infection Rate = DELAY1I (Contact Rate c,4,Contact Rate c)*Infectivity i*Susceptible Population S*Infectious Population I/Total Population P

Units: People/Day

The infection rate is the total number of encounters S multiplied by the probability that any of those encounters is with an infectious individual I/P, and finally multiplied by the probability that an encounter with an infectious person results in infection i.

(08) Infectious Added = 10

Units: People

Ten infectious individuals arrive every day until period 18 from the day of the coronavirus patient zero.

(09) Infectious Population I = INTEG (Immigration of Infectious+Infection Rate-Recovery Rate in Progress,0)

Units: People

The infectious population accumulates the infection rate and the immigration of infectious rate less the recovery rate in progress.

(10) Infectivity I = 0.1527

Units: Dimensionless

The infectivity (i) of the disease is the probability that a person will become infected after exposure to someone with the disease.

(11) Initial Contact Rate = 1

Units: 1/Day

The initial contact rate; the actual contact rate rises at a slope determined by the user.

(12) INITIAL TIME = 0

Units: Day

The initial time for the simulation.

(13) Recovered Population R = INTEG (Recovery Rate,0)

Units: People

(14) Recovering Population = INTEG (Recovery Rate in Progress-Recovery Rate,0)

Units: People

(15) Recovery Rate = DELAY FIXED (Recovery Rate in Progress,12, Recovery Rate in Progress)

Units: People/Day

The rate at which the infected population recovers and becomes immune to the infection.

(16) Recovery Rate in Progress = (Infectious Population I-Deaths)/Average Duration of Illness d

Units: People/Day

(**17**) Reproduction Rate = Contact Rate c*Infectivity i*Average Duration of Illness d*Susceptible Population S/Total Population P

Units: Dimensionless

(**18**) SAVEPER = TIME STEP

Units: Day

The frequency with which output is stored.

(**19**) Susceptible Population S = INTEG (-Infection Rate, Total Population P - Infectious Population I-Recovering Population)

Units: People

The susceptible population, as in the simple logistic epidemic model, is reduced by the infection rate. The initial susceptible population is the total population less the initial number of infectives and any initially recovered individuals.

(**20**) TIME STEP = 0.0078125

Units: Day

The time step for the simulation.

(**21**) Total Population P = 10000

Units: People

The total population is constant.

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