

## The Coronavirus Pandemic - a Systemic overview

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### Abstract

The Coronavirus pandemic is a major challenge to human wellbeing; it directly affects health, and indirectly involves the economic, politic and social spheres. This, in turn, is going to have major systemic, worldwide health, social and environmental consequences. In this paper, I will briefly sum up the history of the pandemic, the worldwide diffusion, the major different political reactions, as well as health and political countermeasures, and the economic consequences / evaluations for the future.

The aim of this paper is to show and address all the different spheres involved and their relationships. Emphasis will be placed on the paradoxical presence of a large amount of data and the big uncertainty for the future.

The outcomes will be briefly analyzed on a healthcare, political and socio-economical level. The point of view is systemic with human beings, institutions and the environment seen as a whole. Systemic thinking allows interdisciplinary research to be decisive in understanding the worldwide reaction to the pandemic.

The global response to this crisis is of historical significance, and therefore potentially decisive for the multi-layered future of the world.

**Keywords:** COVID-19, Pandemic, Health policies, Finance, Systems Thinking

## Introduction

The current pandemic is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It is a new virus, a close relative of SARS-CoV (Zhou et al, 2020), first discovered in the human population of Wuhan City, Hubei Province (China) in December 2019 (Volz et al. and CHP Hong Kong 2020).

As of 9th June 2020, there have been 7,217,163 confirmed cases and 409,095 deaths of Novel Coronavirus Disease (COVID-19) reported worldwide; 212 countries and territories are affected (WHO, 2020). Sustained transmission is currently ongoing in several countries outside China. The United States, European countries (in particular UK, Russia Italy and Spain), and Brazil are the most affected. It was declared a pandemic by WHO on March, 11th 2020 (WHO, March 2020). There were more than 118,000 cases in 114 countries.

This pandemic has presented unprecedented challenges to the healthcare systems in a lot of countries around the world.

Thus, unprecedented interventions have been implemented in order to suppress or mitigate the initially exponential transmission of SARS-CoV-2.

The main health concerns and dangers about the spread of COVID-19 are: a) the novelty of the virus and the rapidly changing knowledge and data about it. b) The high contagion rate ( $R_t$ ). c) Uncertainties regarding the transmission dynamics of the virus. In particular, there is still debate on virus transmission of asymptomatic versus symptomatic patients (Mizumoto et al., 2020). Furthermore, the incubation times are quite long (2-14 days). d) About 20% of cases require hospitalization in isolation and / or hospitalization in intensive care. This is the main reason why there is so much attention to mitigate the spread of the

virus. e) The death toll also remains uncertain, due to the difficulties in recording homogeneous data among all states, and because of the lack of a denominator. f) We have no effective drugs or vaccines (Zunyou and McGoogan, 2020). Chloroquine/Hydroxychloroquine (old antimalarial) results about clinical effectiveness are controversial (Hashem et al, Shukla et al, 2020).

This pandemic is a global stressor, able to stretch our systems and countries, our individual health (physical and emotional), our health systems, and our worldwide organizations. It is a pandemic that completely undermines the multi-level organizational system, because it has exponential characteristics and trends. The infection rates are exponential, consequently the number of people that are seriously ill - and the number of deaths - continue to increase.

The progressive and increasingly totalizing quarantine creates a chain of consequences, which are amplified exponentially even in the economic sphere. In the middle, there is the political, bureaucratic and social web, which is complex, therefore stable and not built to support and change easily within such wide and volatile dynamics.

So, the linear and stable infrastructure of our socioeconomic organization is massively stretched by the non-linear and exponential dynamics arisen by the virus' spread.

In this paper, we are going to explore an overview of the three most affected spheres: health, politics, socio/economics. We will then briefly look at some possible scenarios for the next phases of the global pandemic.

This paper is based on a monistic view of all the human spheres and of the environment, with a coherence and equal respect to different disciplines and ecosystems. By reasoning in these terms, not only can we better respond to this pandemic, but we can also aim for a new way of developing our society. We will then reach a deep change in our organizational paradigms that may become more resilient and adequate to big upheavals.

## The health sphere

The COVID-19 infection can lead to a variety of symptoms and clinical pictures. The main symptoms of COVID-19 are fever, cough, dyspnoea, sore throat, fatigue, headache, conjunctivitis and gastrointestinal issues. The clinical pictures go from mild patterns to severe patients, with ARDS (Acute Respiratory Distress Syndrome) and/or DIC (Disseminated Intravascular Coagulation). The most diffused diagnostic tool is PCR (Polymerase Chain Reaction), using a nasal swab and tracheal aspirate or bronchoalveolar lavage samples. Computed tomography is used for both diagnosis and the follow-up (Pascarella et al, 2020)

This pandemic has enormously stressed the health systems of a lot of countries.

In fact, the rapid spread of this contagion, the severity of a lot of patients, the difficulties in diagnosis, isolation and tracking of patients, the hospitalization for long periods of time, and the necessity of ventilation, have increased the need of the healthcare system.

In Wuhan, during the peak there has been a total of 11,537 hospital beds, an increase of 71%. There were only 6,754 beds in the town before COVID-19 (6parknews.com, 2020).

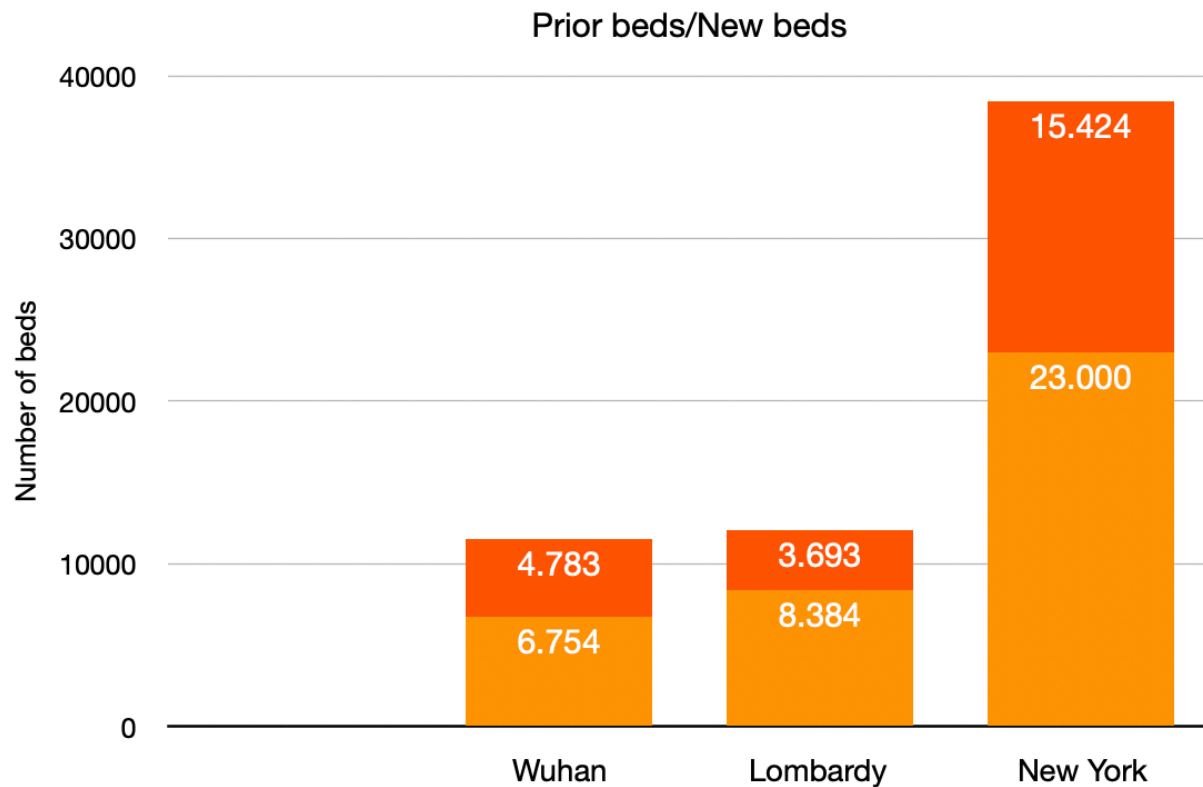
In Lombardy, Italy, another clou region, the proportion of ICU admissions represented 12% of the total positive cases, and 16% of all hospitalized patients. Pre-crisis, the total ICU capacity was approximately 720 beds (Grasselli et al, 2020). 741 have been added (truenumbers.it, 2020). The highest number of ICU patients in Lombardy has been 1,351 on April, 2nd. The number of hospital beds in 2017 (last data) in Lombardy were 8,384 (nextquotidiano.it, 2020). The highest number of hospitalized patients that didn't need ventilation has been 12,077 on 14th, April (covid19.lbreda.com, 2020). (Tab 1, Graph 1)

In New York, another pandemic epicenter, prior to the pandemic there were 23,000 existing beds. By April 27th, they had managed to add 15,424 beds, reaching a total bed

capacity of 38,424 (Bloomberg, 2020). In Lombardy the increase had been specifically ICU beds; in the other two regions analyzed here, they were just ordinary beds.

	Prior Capacity	New Beds	Total	% increase
Wuhan, China	6754	4783	11537	71
Lombardy, Italy	8384	3693	12077	44
New York, USA	23000	15424	38424	67

Tab 1. Prior capacity, hospital ordinary beds added, total beds and % of increase in the three regions analyzed.

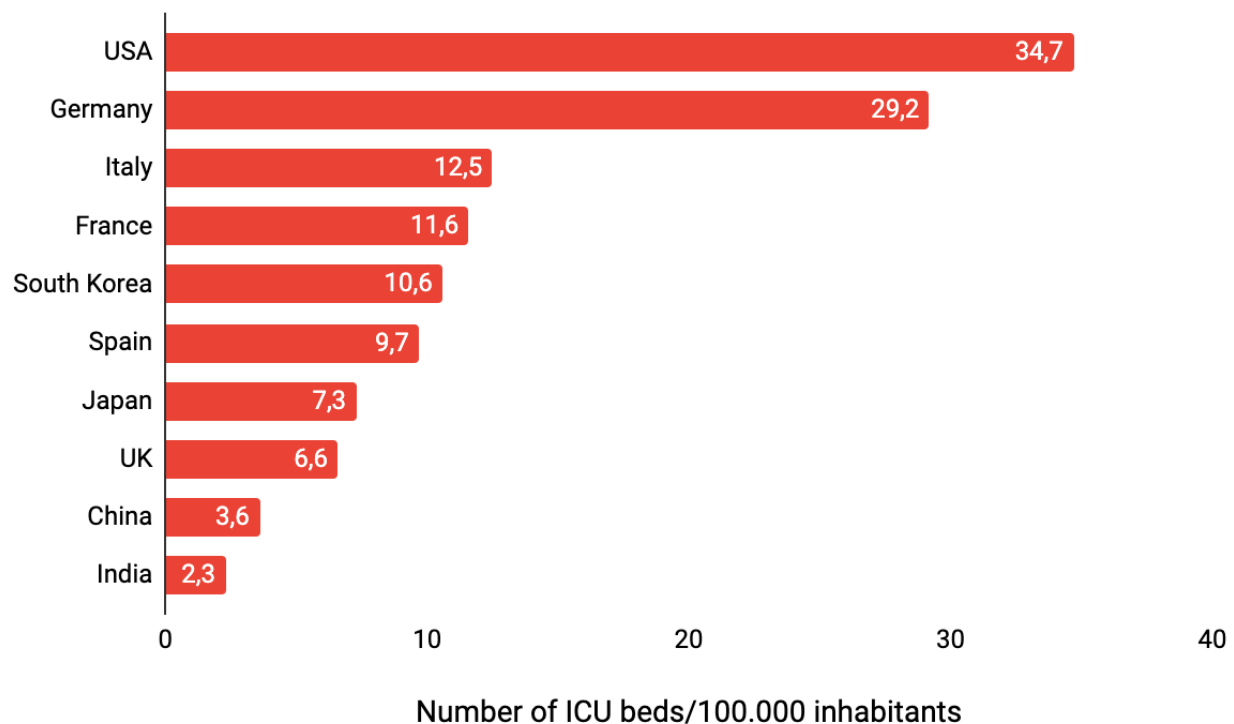


Graph 1. Prior capacity and hospital ordinary beds added in the three regions analyzed.

In managing the spread of the contagion, the pre-existing organization, facilities and cost of the health system had a critical role. If we analyze Europe, one of the most organized countries is Germany, with a total of 26,000 ICU beds prior to the pandemic. They didn't need to increase them. Germany has a rate of 29.2 ICU beds per 100,000 inhabitants. In the US, this rate is 34.3; in Italy 12.5, in France 11.6 and in Spain 9.7 (Rhodes et al, 2012). (Graph. 2)

Per capita healthcare spending in Germany in 2012 was \$ 4,811 (of which \$ 3,651 - 75.9% - is public). They spend much lower than the United States (\$ 8,745), but much higher than the OECD average (\$ 3,484), that of Great Britain (\$ 3,289) and Italy (\$ 3,209). Following the financial crisis of 2008, Germany, like the average of the OECD countries, experienced a sharp slowdown in the annual growth in healthcare spending, which went

from + 4% in 2008 to slightly less than + 1%, while other Southern European countries have suffered a sharp reduction in available resources in real terms: Spain -2%, Italy -3%, Portugal -6%, Greece -10% (Salute Internazionale 2014, OECD 2020). This played a critical role in the management of the pandemic.



Graph 2: Prior number of ICU beds per 100,000 inhabitants in selected countries. Source Rhodes et al, 2012

If we see the health system as a network, the most involved nodes in responding to the pandemic are:

- 1) Territory: the most distributed and consequently the most difficult part to organize. On territory patients must receive diagnosis through tampons, the first treatments, and monitoring of their health condition. The involvement of territory medicine has been controversial, because originally there weren't therapeutic-specific protocols, and

MDs needed to receive enough PPE (personal protective equipment). Scaling the resources to diagnose has also been challenging. South Korea shared one of the most efficacious protocols (Ki Ho Hong et al, 2020). On territories, and in particular within families, there is another crucial phase: the recovery after hospitalization. The management of quarantined patients is critical and very important, in order to avoid further contagion among members of the same family. Quarantine is actually reported as the safer method in order to reduce deaths (Ghosal 2020).

- 2) Ambulances: there needs to be a reorganization in order to guarantee separation between COVID suspects and other patients. They are massively involved in the peak phase, because of the acute Respiratory Distress Syndrome, and so their difficulty is in managing urgencies and guaranteeing punctual arrival and treatment of all critical patients. In fact, in the peak phase, there is the risk of not treating patients with other pathologies because of overloading the emergency chains.
- 3) Hospitals and ICU: not only have a lot of countries added hospital beds, but the quality of organization has changed. In fact, entire hospitals have been reorganized in order to treat only COVID patients. So, entire hospital wards and/or structures are dedicated to COVID management. In Lombardy, the hospitals were requested to a) create special ICUs for COVID-19 patients. This means areas separated from the rest of the ICU beds, in order to minimize risk of in-hospital transmission. b) Establish protocols for the triage of patients with respiratory symptoms, to test them rapidly, and, depending on the diagnosis, allocate them accordingly. c) Organize a triage area where patients with suspected COVID-19 infection could receive mechanical ventilation, pending the final result of diagnostic tests. d) Ensure that adequate personal protective equipment (PPE) for health personnel is available, with adequate training for all personnel at risk of contagion. e) Report every positive or suspected critically ill COVID-19 patient to the regional coordinating center. In order to quickly make ICU



beds and personnel available, not urgent procedures were canceled. In total, over the first 18 days, the network created 482 ICU beds ready for patients (Grasselli et al, 2020).

## **The scientific/medical uncertainties**

Although we now know a lot more than at the beginning, this pandemic includes a lot of uncertainties.

There is still debate on the real numbers of those infected in the different countries.

A study by the Imperial College in London says there could be 10 million positive cases, in Italy alone (Imperial College COVID-19 Response Team, 2020). They estimated 10% of the population was already infected by the end of March, 15% in Spain, and less than 1% in Germany. Of course, the different latency in spreading and peaks plays a fundamental role in these considerations.

Another estimate published in JAMA, which takes into account Chinese mortality, speaks of 65% of cases not being recognized (Zunyou Wu and McGoogan, 2020).

These models need to be periodically updated according to the data.

The difficulty in doing epidemiological models is a fundamental one: currently the denominator isn't known. That is, the total number of infected, including asymptomatic or mild ones. Without a denominator, it is impossible to have reference points on the real death toll, and the real dimensions of the problem. Another difficulty in this sense is the dissimilarity in diagnostic protocols among different regions and countries.

The risk is to waste precious time to understand more and to protect the population.

Another source of uncertainty are therapies. One of the most important published reviews concluded that unfortunately there are currently no efficacious therapies (Sanders et al,

2020). They gave hope to Remdesivir, an antiviral that is now being experimented with through several trials.

Although no specific drug has been previously approved for the COVID-19 treatment, there are some protocols in order to treat people at home or in hospital, using a combination of chloroquine, antivirals, monoclonal antibodies, and anticoagulants (Lombardy Section Italian Society Infectious And Tropical Diseases, 2020).

The convalescent plasma infusion of healed patients is also being tested to help sick patients develop antibodies (Brown and McCullough, 2020). It is a promising treatment with proven efficacy and relatively low costs.

We come to another source of uncertainty: immunity. Is it permanent? We need time to discover it. An analysis showed that, out of 285 patients, 100% of them developed IgG (memory antibodies) within 19 days of infection; everyone had already developed IgM, as is normal (Long et al, 2020). How long will they last, is not yet known.

The problem of the duration of immunity is also central to another question: the development of the vaccine. There are currently more than 70 attempts underway, of which 4-5 are already in the experimental phase (Tung Thanh Le et al, 2020).

One of the most famous attempts, experimented by the University of Oxford and already in the Phase I Clinical Trial on humans (Oxford Vaccine Group, 2020), showed no efficacy in reducing the viral loads in rhesus macaques. They only had milder symptoms in comparison with the control group (van Doremalen et al 2020).

We do not know the genomic evolution of this novel Coronavirus. The latest estimate mutation rate in the genome is  $0.80-2.38 \times 10^{-3}$  nucleotide substitution per site per year. This is in the same order of magnitude of other RNA viruses (Zhao et al 2020). Different and casual evolutionary lines could lead to milder or worse infections.

Of course, there is uncertainty about the duration of the pandemics, about the “when” and “where” of peaks in different nations.

On a sanitary level, a lot of indirect effects need to be considered and are still under investigation.

For example, psychological consequences in health professionals and the population under lockdown or strict measures needs to be better evaluated (Holmes et al 2020). There is preliminary evidence that suggests symptoms of anxiety and depression (16-28%) and self-reported stress (8%) as common psychological reactions to the COVID-19 pandemic, which may be associated with disturbed sleep. The available literature has emerged from only a few countries; there is a need for more experimental research from other affected countries, particularly in vulnerable people/patients (Rajkumar, 2020). This is particularly valid for children.

The other example reported here is about indirect deaths, because of lack of resources dedicated to other pathologies during the most intense phases of the outbreak.

Oncology, scheduled operations, some types of cancer treatment, and appointments are being cancelled or postponed (The Lancet Oncology editorial, 2020).

A study done in Hong Kong showed an increase of complicated in-hospital courses and worse outcomes in myocardial infarction (Chor-Cheung Frankie Tam et al 2020).

Maternal and child mortality increase due to the acute outbreak has been molded in low- and middle-income countries, but not proven (Roberton et al 2020). Other studies to evaluate these long-term and indirect impacts are needed.

## **Political countermeasures**

The exponential growth of the epidemics and the overwhelming of health systems led the countries involved to develop political and sanitary countermeasures.

In late December 2019, a 34-year-old MD (ophthalmologist) from Hubei, Dr. Li Wenliang, alerted officials about a new virus that was causing a form of atypical pneumonia, spreading fast. In early January, he was forced to sign a statement of unfounded and illegal rumor. On February 7 2020, Dr. Li Wenliang died because of Covid-19 (Green 2020).

China was only the first state that delayed in taking appropriate measures.

In China, especially in Wuhan and the region of Hubei, a strict quarantine had been imposed by the beginning of February; all industries and public places were closed, people had to remain at home, and they could only go for groceries every two days. The borders of the region had been closed. Detention as in place for those who disobeyed. It lasted more than two months (Bloomberg 2020).

In Europe and western countries, Italy has been the first nation to be massively involved after China, although “patient 0” in Europe was probably German (Zehender et al 2020). The first case was diagnosed on February 15, 2020. Two main clusters were identified by the Italian National Institute of Health (ISS): one in Lombardy, and the other one in Veneto. On February 23, 11 municipalities in these regions were placed under quarantine (Gazzetta ufficiale Italiana, 2020a). Italy was also the first European country to implement lockdown (Gazzetta ufficiale Italiana, 2020b).

When Italy, an EU member state, was hit and started to adopt strategies to flatten the curve, other EU member states didn’t capitalize much from the Italian experience.

The EU reacted in an uncoordinated, uncooperative and inhomogeneous way (Posocco and Diani 2020). Not only did states adopt different measures, but their timing and the logic behind them was also different. The EU was not prompt, not only in terms of economic interventions, as we state in the next section, but also in the regulation of knowledge

sharing, medical treatment, and testing. In the first phase of contagion, each country implemented its own strategy according to its own schedule.

They have been very different: Italy, France and Spain adopted a strict lockdown. Germany imposed school closures, social distancing, and curfew, but industries remained open. Netherlands and particularly Sweden adopted less strict countermeasures.

Regarding testing, Germany was the first country in terms of the number of tests carried out to track down the virus, followed by Italy, Spain, France (Statista 2020). The well-timed testing and isolation are supported by Ferguson's study and the WHO (Ferguson et al 2020), and this may explain the reason why after the initial outbreak in Germany, the curve flattened earlier than in other countries.

In general, the majority of countries adopted different combinations of these countermeasures: home isolation of cases, school closure, public events banning, social distancing, in particular of those over 70 years old, household quarantine (lockdown).

Ferguson et al. (2020) analyzed the efficacy of these measures in order to mitigate or suppress the spread of the virus. According to this study, the least satisfying results came from the school closure measure. This explains why those countries that, like Italy, closed schools prior to any other measure, saw a rapid increase of cases.

The most effective results are obtained by combining household quarantine, home isolation of cases, and social distancing, in particular of those over 70 years old. This strategy was implemented in Europe, although not promptly, by Italy, Spain, and France which at present observe the flattening of the contagion curve (ECDC, 2020).

The pandemic spread into the US on March 11th, where there were more than 1,000 cases.

The American federal government first implemented some travel restrictions for people from China, Iran, the 26 European countries that comprise the Schengen Area, the United Kingdom and Ireland (Woodyard 2020).

On March 16th, Trump announced "15 Days to Slow the Spread" — a series of guidelines based on CDC recommendations on topics such as physical distancing, self-isolation, and protecting fragile people. The government also recommended closing schools and avoiding gatherings of more than ten people (whitehouse.gov, 2020).

Throughout March and early April, several state, city, and county governments imposed "stay at home" quarantines on their populations to stem the spread of the virus (Norwood 2020).

On April 28th, the total number of confirmed cases across the country surpassed 1 million (Almasy et al, 2020). The US has the highest number of cases in the world.

After affecting the US, the pandemic spread to Brazil. The first 1,000 cases were reached by the 21st of March. President Bolsonaro refused to close businesses or postpone activities because this would damage the economy (BNews 2020). He criticized the governor of Rio de Janeiro, Wilson Witzel, for asking for the suspension of flights from the most affected states (noticias.uol.com.br 2020). Bolsonaro has compared the Covid-19 to a "little flu", consequently enacting less countermeasures (noticias.uol.com.br 2020).

The last most involved country is Russia: the first 1,000 cases were reached by the 27th of March (Zhou et al, 2020). The Russian government also avoided travel from the most affected countries.

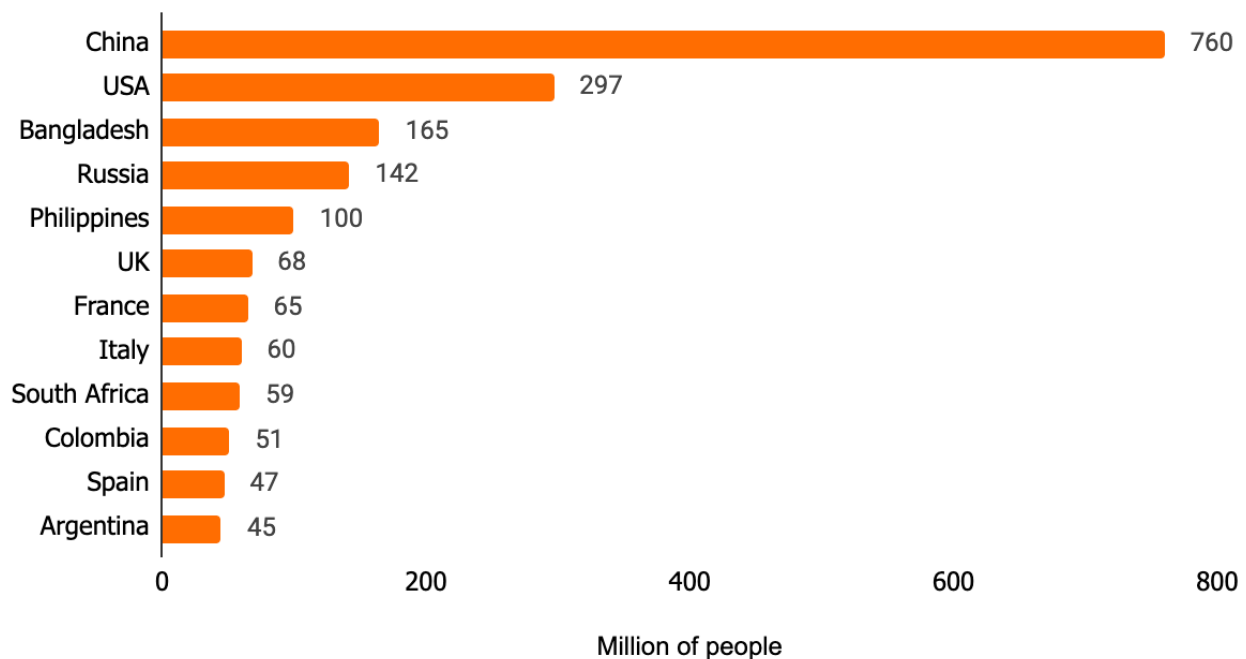
Russia implemented countermeasures such as quarantine and facial recognition.

In particular, on 30th March, Moscow and Moscow Oblast declared a lockdown. All regions were urged to follow the example and take similar measures. The lockdown was then extended to the other federations (nidm.gov.in 2020). Russia now has the third highest number of cases in the world.

By the end of April, one third of the world's population was placed on lockdown (Buchholz 2020) (Graph. 4). Schools, universities and colleges have closed either on a nationwide or local basis in 177 countries, affecting approximately 98.6 per cent of the world's student population (UNESCO 2020). During quarantine, only essential businesses are allowed to remain open.

These worldwide countermeasures have led to huge economic, financial, environmental and social consequences.

### Number of people placed on lockdown, per country



Graph. 4: Number of people placed on forced lockdown due to the Covid-19 pandemic, per country (in million people).

Note 1: in the US and UK the lockdown has been at least partially enforced.

Source: Buchholz K (2020)

## Socioeconomical sphere

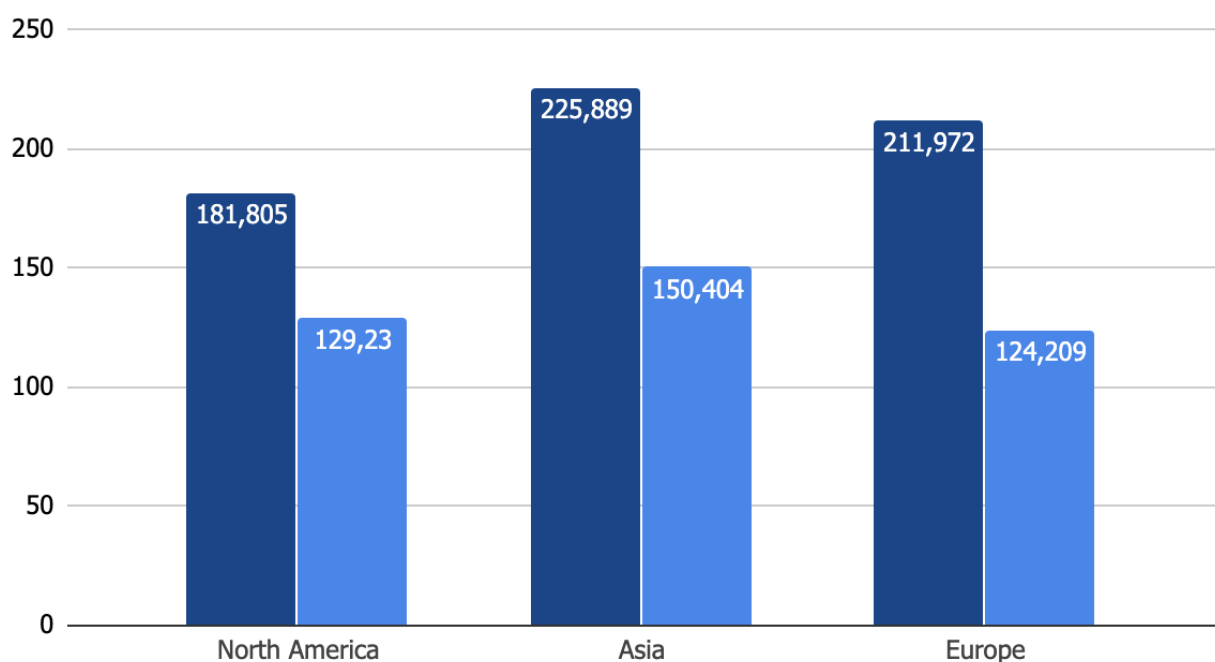
If we consider the real economic sphere, we can note a lot of data expressing the huge consequences of worldwide countermeasures against the pandemic's spread.

In particular, the most representative example is the decrease of revenue in tourism.

The forecast made by Statista (2020) is based on the following assumptions: a) The epidemic will have a major impact on travel and tourism for the whole year of 2020. b) The basis for the estimations has been IATA's forecast about the overall effect of COVID-19 on the flight industry. c) The decreased demand for flights coincides with the reduced demand for leisure trips in general.

According to these assumptions, North America may register -29.8% on the annual revenues, Asia -33.4% and Europe -41.4%. Europe could face the biggest damages and the most affected country will be probably Italy, with -44.9% (Statista 2020).

Revenue forecast in million US\$ by region - 2019 vs 2020



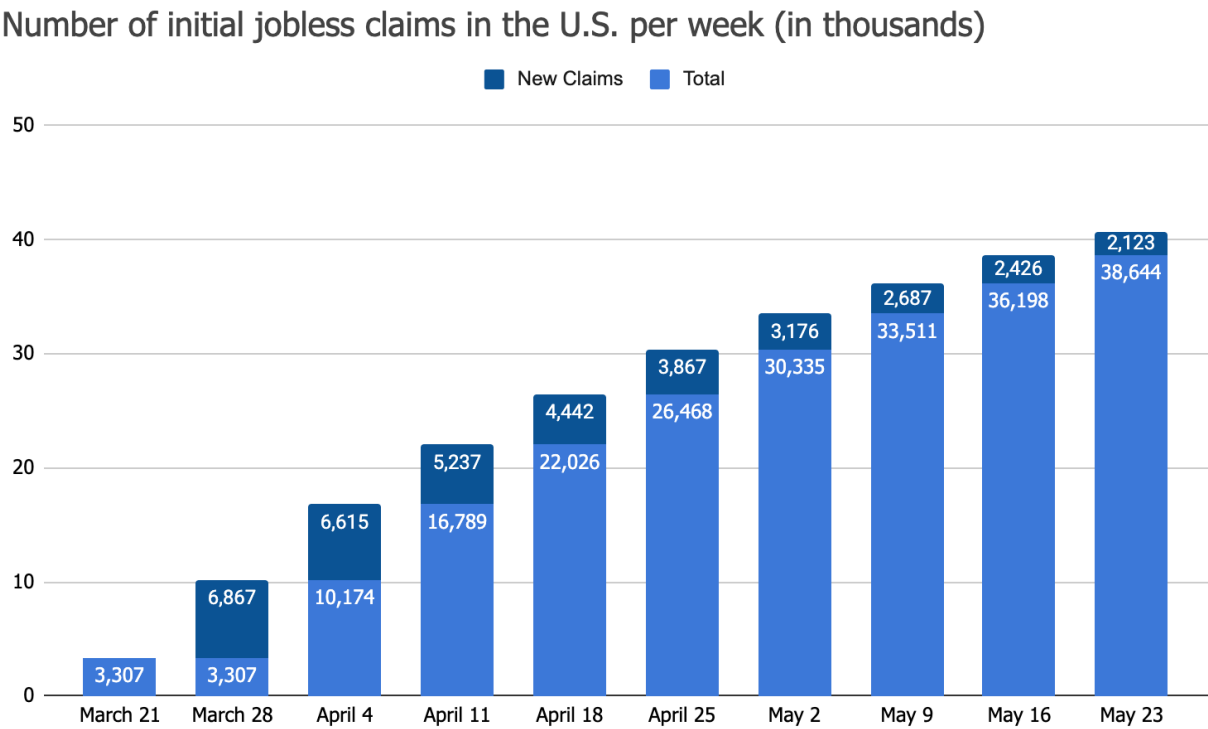


Graph 5. Comparison between the 2019 revenue and the 2020 forecast in tourism between North America, Asia and Europe. Source: Statista 2020.

While online businesses are globally experiencing a growth in page views and transactions (contentsquare.com 2020, Statista 2020), there are a lot of sectors involved in the worst economical crisis since WWII.

Even in Sweden, one of the countries with the less stringent measures adopted, bankruptcies are increasing, particular in restaurants, in the scientific, law and economic field, and in transportation (uc.se 2020).

In the US, jobless claims are increasing each week, surpassing 40 million in 10 weeks (from the end of March to the end of May) (U.S. Department of Labor 2020a, Roper W 2020). In April the unemployment rate rose to 14.7% (U.S. Department of Labor 2020b).



Graph 6: Number of initial jobless claims in the US per week (in thousands). Source Roper W (2020)

As Professor Fernandes states, comparisons with other global crises, like the 2008 financial crisis, are not possible. This is because of some new challenges: "a) It is a global pandemic, b) It is not focused on low-middle income countries, c) Interest rates are at historical lows, d) The world is much more integrated, e) This current crisis is generating spillover effects throughout supply chains, f) We have simultaneous destruction of demand and supply." (Fernandes 2020).

Worldwide GDP losses in 2020 can only be estimated at the present; the different pandemic scenarios influence the severity of the economical fluctuation (World Bank 2020, Bloomberg 2020).

The economic and financial countermeasures will have a fundamental role in the systemic worldwide organization.

Here we will report primarily the strategy of the European Central Bank (ECB) and of the Federal Reserve System, commonly known as the FED.

In Europe, Christine Lagarde, President of the European Central Bank (ECB), initially declared, “I am not here to close spreads” (Reuters 2020). She also stated that the EU would provide “cheap loans” to the countries in need. These declarations generated panic. The following day Italy registered the record fall of the Milan stock exchange, with a loss of 17% and 68 billion Euros (Ansa 2020).

After the explosive market reaction, Lagarde reassured the markets and Italy, together with the President of the European Commission, Ursula von der Leyen, who on March 13th, 2020, said, ‘We’ll give Italy all it asks for’ (Ansa 2020).

In the same days, the ECB started a program of Tender Operation-Allotment of more than 140 billion dollars (ECB 2020).

On 15th March, 2020, The Bank of Canada, The Bank of Japan, The Bank of England, The European Central Bank, The Federal Reserve, and The Swiss National Bank announced a coordinated action to enhance the provision of liquidity using the standing US dollar liquidity swap line arrangements.

They have agreed to lower the pricing on the US dollar liquidity swap arrangements by 25 basis points; they have also agreed to begin offering US dollars weekly in each jurisdiction with an 84-day maturity, in addition to the 1-week maturity operations already present.

So, they used the swap lines as an important liquidity backstop to ease strains in global funding markets, thereby helping to mitigate their effects on the supply of credit to households and businesses, both nationwide and abroad (ECB 2020). Swap lines have been

enhanced because of the strong demand for dollars; they allow foreign central banks to temporarily exchange their currency for dollars with the FED. When the swap is concluded, the foreign central bank will return the dollars, with interest, to the FED and the FED returns the foreign currency. For ECB, the interest rates are between 0.3 and 0.35% (ECB 2020).

In addition to this program, the FED created a foreign central bank (FIMA) repo facility. The facility, which also charges interest, allows foreign central banks to temporarily exchange their US Treasury securities for US dollars (Congressional Research Service 2020).

The dollar dominance, that begun after the Bretton Woods Conference, is not only diminishing, but probably arising. In fact, today more than 61% of all foreign bank reserves are denominated in US dollars, and nearly 40% of the world's debt is in dollars (Investopedia, 2016). These measures will probably increase the dollar dominance in the short-medium term, although the future trend is still under debate (Huo Li 2020).

This increase in the dollar worldwide dominance (Miller 2020) may have huge strategic and geopolitical consequences. This is one of the unknowns that we have about the long-term future.

Regarding the internal US policy, the FED allocated the record amount of 2.3 trillion dollars (around 11% of GDP) with the “Coronavirus Aid, Relief and Economy Security Act, CARES Act (congress.gov 2020). The Act includes (a) 293 billion dollars to provide one-time tax rebates to individuals; (b) 268 billion dollars for unemployment benefits; c) 25 billion dollars to provide a food safety net for the most vulnerable; d) 510 billion dollars to prevent corporate bankruptcy by providing loans and guarantees; e) 349 billion dollars in forgivable Small Business Administration loans and guarantees to help small businesses

retain workers; f) 100 billion dollars for hospitals; (g) 150 billion dollars for different states and local governments and (h) 49.9 billion dollars for international assistance (International Monetary Fund, 2020).

Until now, these policies have been very different from the ECB and European Commission ones. In fact, the European Commission's latest package of about €540 billion (4% of EU27 GDP) includes: a) allowing the European Stability Mechanism (ESM) to provide Pandemic Crisis Support (based on existing precautionary credit lines and strict conditions/monitoring for the payback of loans (Huo Li, 2020) up to 2 percent of 2019 GDP for each euro area country. It is meant only to support direct and indirect healthcare, cure and prevention related costs due to the COVID-19 crisis; (b) providing €25 billion in government guarantees to the European Investment Bank (EIB) to support up to €200 billion to finance to companies; (c) creating a temporary loan-based instrument (SURE) of up to €100 billion to protect workers and jobs, supported by guarantees from EU Member States (IMF 2020).

Each state is still evaluating the opportunity of activating ESM, because of the strict conditions posed by Germany, Netherlands, Denmark and Austria in the use and payback of the loans. The lack of solidarity between different countries appears as a fact (Posocco and Diani 2020).

These measures ratified by the European Commission and/or the ECB are in the form of loans.

On 18th March, the ECB announced the 750 billion euros Pandemic Emergency Purchase Programme (PEPP). The purchase concerned private and public sector securities, and it was thought to be planned along the entire 2020 (ESM 2020). The first purchases up until the end of May had been mostly of sovereign debt, as expected. Most of the private sector debt that the bank bought (76% of the 46 billion euros in that segment) was in the commercial paper market (ECB, 2020).

On the 4th of June, the ECB announced an extension of PEPP until 2021 with additional 600 billion euros (investing.com, 2020).

The internal struggle within Europe, with the recent sentence of the Karlsruhe Court (Financial Times, 2020), may have huge impact on the future, both in the survival of the monetary union and the role of Europe in the world trades.

If we consider the percentage of GDP that main countries, federations and unions allocated to counterbalance the COVID-19 economic crisis, we see that in Japan the fiscal stimulus package amounts to 21% of GDP. In the US, 11%. Australia and Canada follow with 9.8%. The European Union allocated just 4% of the GDP (International Monetary Fund 2020, Statista 2020, Reuters 2020).

The social network may also change with this global crisis, and with that the social habits and relationships, psychology and health. We see the circularity and the interdependency of all these areas, and this brings us to the systemic discussion.

## **Discussion - the systemic view**

We have so far seen examples of huge consequences and impacts on health systems and organizations, politics, economics and finance that the initial exponential spread of the pandemic caused.

The medium between the virus and these impacts is the ensemble of national and world-wide countermeasures. Hence, we may not consider the virus on its own, but rather the human response to it.

Positive changes occurred on an environmental level: during lockdown, the CO<sub>2</sub> emission dropped to levels not seen since the '60s. A global reduction is expected throughout 2020 (Tolleson 2020, Le Quéré 2020), and this could slow down global warming.

Besides quantitative environmental changes, there are some surprising events. For example; in Venice water became very clear after a few weeks of lockdown (The Guardian 2020); in India, the Himalaya peaks were visible after 30 years (CNN, 2020); in a lot of countries the number of baby turtles on the beaches increased (BBC, 2020).

It becomes evident how different systems are interconnected. It is likely politicians did not have a clear idea of the impacts of their decisions. Of course, they were focused in slowing down the pandemic spread, justified by evident needs and by important epidemiological studies. The overall impact of “only” two months of lockdown, with closure of schools, public events, travel, and businesses wasn’t clear.

The way to properly interpret all these events is systems thinking.

Systems thinking implies the consideration of the circular nature of the world. It requires an awareness of the role of structure and networks in creating the conditions we face; a recognition that there are laws of systems and connections that we are unaware of. Finally, it allows a realization that there are wide and indirect consequences to our actions.

Systemic logic is different from the linear one, because it isn’t built of direct and mono directional causes and consequences; it is rather made of direct or indirect correlations, feedback circuits, non-linear amplifications as well as macroscopic stability (Bar-Yam, 2002). A complex system is representable as a network with distributed nodes and connections. A living complex system is cognitive, with the ability to elaborate information (Park and Barabási 2007, Maturana and Varela 1980).

We can see the earth as the bigger complex system, so a system of systems (Baldwin and Sauser 2009); as observers, we can be aware of the self-regulation of the entire world, of the interdependency and relationships among the different spheres of life (Capra and Luisi 2016).

So, this pandemic is undermining the entire world organization, at all levels. The decisional, local, national, international structures are built to be stable, linear, distributed but with central control. This lashed out against the non-linear, exponential nature of viral spread. The intrinsic characteristics of the virus (i.e. virulence, contagion rate, mutation rate) created the perfect storm.

In this paper I have shown some quantitative examples of the consequences, together with qualitative ones. For example, the change in the hospital organization, the shift in consumptions, with local businesses closed and online businesses rising.

We will probably see, at a distance, impacts on the most fragile portions of the population (women and young people) and differences between the more- or less-developed countries.

On a strict medical level, the pandemic spread could have another peak phase in the future, or not (Kissler et al 2020). Its dimension and consequences aren't known.

Will the smart working during these months have a long-term impact on the work organization and perception? Will social distancing and fear contribute to changes in our social habits and human relationships? Will prolonged school closure have an impact on children's health? Will the European Union survive? Will dollar dominance increase or change? Will geopolitics change? Will the economic crisis change paradigms and deeply embrace ecology?

Will the general segmented, local, disconnected perception change towards a more systemic one?

These remain open questions. In complex systems, there is the contemporary presence of non-linearity (predisposition to disproportional consequences from small initial events) and stability, both given by interconnection and interdependency.

In the long-term, will the stability of the "Earth complex system" win, or will the non-linear and global changes prevail?



The intrinsic unpredictability is caused by these systemic properties and remain even with the large amount of data in different sectors that we are collecting.

## Conclusion

In conclusion, we are living a global event with a historical significance. The challenges for our society are huge. The quantitative and qualitative long-term outcomes are not predictable.

The economic crisis could have a bigger impact than the disease itself. It is important to be aware that this depends on the systemic, politic and economic reaction to the exponential growth and consequently on the saturation of hospitals and healthcare systems. The emotional component (i.e. fear, anxiety) in the decision-making process is not calculable, but could play an important role.

On the other hand, this challenge potentially allows us an important individual and collective evolution.

The final discussion is based on a monistic view of all the human spheres, of the environment, with coherence and equal respect to different disciplines and ecosystems. By reasoning in these terms, not only we can better respond to this pandemic, but we can also aim for a new way of developing our society.

We will then reach a deep change in our organizational paradigms, that may become more resilient and adequate to big upheavals.

In fact, it is a period that requires wisdom.

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## References

6parknews.com (2020) <https://www.6parknews.com/newspark/view.php?app=news&act=view&nid=399253>

Almasy S, Maxouris C, Chavez N. "US coronavirus cases surpass 1 million and the death toll is greater than US losses in Vietnam War". CNN. <https://edition.cnn.com/2020/04/28/health/us-coronavirus-tuesday/index.html> Retrieved April 29, 2020

Ansa (2020) Milan bourse closes almost 17% down [http://www.ansa.it/english/news/business/2020/03/12/milan-bourse-closes-almost-17-down\\_cd2da817-ad7d-46c8-a2ae-74071926e96c.html](http://www.ansa.it/english/news/business/2020/03/12/milan-bourse-closes-almost-17-down_cd2da817-ad7d-46c8-a2ae-74071926e96c.html)

Ansa (2020) We'll give Italy what it asks for - Von der Leyen. [http://www.ansa.it/english/news/2020/03/13/coronavirus-well-give-italy-all-it-asks-for-von-der-leyen\\_7531c574-04e8-4973-9389-c5fcbe2c8ca7.html](http://www.ansa.it/english/news/2020/03/13/coronavirus-well-give-italy-all-it-asks-for-von-der-leyen_7531c574-04e8-4973-9389-c5fcbe2c8ca7.html) Retrieved March 28, 2020

Baldwin WC and Sauser B (2009) Modeling the characteristics of system of systems, IEEE International Conference on System of Systems Engineering (SoSE), Albuquerque, NM, 2009, pp. 1-6.

Bar-Yam Y (2002) General Features of Complex Systems, Encyclopedia of Life Support Systems (EOLSS UNESCO Publishers, Oxford, UK, 2002) <https://static1.squarespace.com/static/5b68a4e4a2772c2a206180a1/t/5c3e1780b8a04538dc61efa2/1547573126626/Paper1.pdf>

BBC (2020) Sea turtles: Why lockdown is great news for these endangered animals. <https://www.bbc.co.uk/newsround/52618038> Retrieved 14 May 2020

Bloomberg.com (2020) Mapping New York City Hospital Beds as Coronavirus Cases Surge <https://www.bloomberg.com/graphics/2020-new-york-coronavirus-outbreak-how-many-hospital-beds/> Retrieved 28 April 2020

Bloomberg.com (2020) Wuhan Sharply Tightens Lockdown of Residents <https://www.bloomberg.com/news/articles/2020-02-13/u-s-ramps-up-criticism-hubei-data-awaited-virus-update> Retrieved 14 february 2020

Bloomberg.com (2020) Coronavirus Could Cost the Global Economy \$2.7 Trillion. Here's How <https://www.bloomberg.com/graphics/2020-coronavirus-pandemic-global-economic-risk/> Retrieved 6 March 2020

BNews (2020) Bolsonaro diz que fechar shoppings e comércio prejudica a economia. Retrieved 20 March 2020.

Brown BL, McCullough J (2020) Treatment for emerging viruses: Convalescent plasma and COVID-19. *Transfus Apher Sci.* 2020;59(3):102790. doi:10.1016/j.transci.2020.102790

Buchholz K. (2020) What Share of the World Population Is Already on COVID-19 Lockdown? <https://www.statista.com/chart/21240/enforced-covid-19-lockdowns-by-people-affected-per-country/> Retrieved April 23, 2020

Capra F, Luisi PL (2016) *The Systems View of Life: A Unifying Vision* (Inglese). Cambridge University Press

Centre for Health Protection of the Hong Kong Special Administrative Region Government (2020). CHP closely monitors cluster of pneumonia cases on Mainland. Available via <https://www.info.gov.hk/gia/general/201912/31/P2019123100667.htm>

CNN (2020) People in India can see the Himalayas for the first time in 'decades,' as the lockdown eases air pollution. <https://edition.cnn.com/travel/article/himalayas-visible-lockdown-india-scli-intl/index.html> Retrieved 9 April 2020

Congress.gov (2020) The CARES Act. Available via: <https://www.congress.gov/bill/116th-congress/senate-bill/3548/text>

Congressional Research Service (2020) COVID-19: Federal Reserve Support for Foreign Central Banks Available via: <https://crsreports.congress.gov/product/pdf/IF/IF11498> Retrieved April 7, 2020

contentsquare.com (2020) The COVID-19 eCommerce Impact Data Hub. <https://contentsquare.com/covid-19-ecommerce-impact-data-hub/>

covid19.[lbreda.it](https://covid19.lbreda.com/region/3) (2020) <https://covid19.lbreda.com/region/3> Retrieved 09 June 2020

ECB (European Central Bank) (2020) Open market operations Available via: <https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html>

ECB (European Central Bank) (2020) Coordinated central bank action to enhance the provision of global US dollar liquidity Available via: <https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200315~1fab6a9f1f.en.html> Retrieved 15 March 2020

ECB (Europe Central Bank) (2020) ECB announces €750 billion Pandemic Emergency Purchase Programme (PEPP). Available via: [https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318\\_1~3949d6f266.en.html](https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318_1~3949d6f266.en.html)

ECDC - European Centre for Disease Prevention and Control (2020) COVID-19 situation update worldwide, as of 9 June 2020 <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

ESM (2020) ESM's role in the European response. Available via: <https://www.esm.europa.eu/content/europe-response-corona-crisis>

Ferguson NM et al (2020) Imperial College COVID-19 Response Team Report 13: Estimating the number of infections and the impact of non-pharmaceutical interventions on COVID-19 in 11 European countries. Available via <https://www.imperial.ac.uk/media/imperial->

college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-Europe-estimates-and-NPI-impact-30-03-2020.pdf?fbclid=IwAR1uW6eX7OdobgWJvbR4ch4LeDptyXdU8-rh1fIVquiDfpY01Iz9RdxusUQU

Ferguson NM et al (2020) Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. Available via <https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf?fbclid=IwAR1TBjyYRWmo0CvTGcirFVvcO62-sc5-o1vfA5Q5L3faQtoRFQ7N2CR5Je60> doi: <https://doi.org/10.25561/77482>

Fernandes N (2020) Economic Effects of Coronavirus Outbreak (COVID-19) on the World Economy 03/2020 doi: 10.2139/ssrn.3557504

Financial Times (2020) What next in Karlsruhe vs ECB? <https://www.ft.com/content/db720dde-19e8-4e9c-bbfb-b4d48db71a6c>

Gazzetta Ufficiale italiana (2020) Decreto del Presidente del Consiglio dei Ministri 23 febbraio 2020 Available via <https://www.gazzettaufficiale.it/eli/id/2020/02/23/20A01228/sg>

Gazzetta Ufficiale italiana (2020) Decreto del Presidente del Consiglio dei Ministri 09 marzo 2020 Available via <https://www.gazzettaufficiale.it/eli/id/2020/03/09/20A01558/sg>

Ghosal S, Bhattacharyya R, Majumder M (2020) Impact of complete lockdown on total infection and death rates: A hierarchical cluster analysis. Diabetes Metab Syndr. 2020;14(4):707-711. doi:10.1016/j.dsx.2020.05.026

Grasselli G, Pesenti A, Cecconi M (2020) Critical Care Utilization for the COVID-19 Outbreak in Lombardy, Italy: Early Experience and Forecast During an Emergency Response. JAMA. 2020;323(16):1545–1546. doi:10.1001/jama.2020.4031

Green A (2020) Li Wenliang. The Lancet Obituary. V. 395, Issue 10225, doi:[https://doi.org/10.1016/S0140-6736\(20\)30382-2](https://doi.org/10.1016/S0140-6736(20)30382-2)

Hashem AM, Alghamdi BS, Algaissi AA, et al (2020) Therapeutic use of chloroquine and hydroxychloroquine in COVID-19 and other viral infections: A narrative review. *Travel Med Infect Dis.* 2020;101735. doi:10.1016/j.tmaid.2020.101735

Holmes EA, O'Connor RC, Perry VH, et al (2020) Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *Lancet Psychiatry.* 2020;7(6):547-560. doi:10.1016/S2215-0366(20)30168-1

Hong KH, Lee SW, Kim TS, et al (2020) Guidelines for Laboratory Diagnosis of Coronavirus Disease 2019 (COVID-19) in Korea. *Ann Lab Med.* 2020;40(5):351-360. doi:10.3343/alm.2020.40.5.351

Huo Li (2020) Will the COVID-19 pandemic reaffirm the dollar's reserve currency dominance? CGTN <https://news.cgtn.com/news/2020-05-16/Will-the-pandemic-reaffirm-the-dollar-s-reserve-currency-dominance--QxlaRW8oE/index.html> Retrieved 16 May 2020

International Monetary Fund (2020) Policy responses to COVID-19 - Policy Tracker. Available via: <https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#U>

Investing.com (2020) ECB Increases PEPP Bond-Buying Program by 600 Billion Euros. <https://www.investing.com/news/forex-news/ecb-increases-pepp-bondbuying-program-by-600-billion-euros-2192159> Retrieved Jun 04, 2020

Investopedia (2020) How the U.S. Dollar Became the World's Reserve Currency <https://www.investopedia.com/articles/forex-currencies/092316/how-us-dollar-became-worlds-reserve-currency.asp> Retrieved March 20, 2020

Kissler SM, Tedijanto C, Goldstein E, et al (2020) Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science* 22 may 2020: 860-868

Le Quéré C, Jackson, Jones MV, et al. Temporary reduction in daily global CO<sub>2</sub> emissions during the COVID-19 forced confinement. Nat. Clim. Chang. <https://doi.org/10.1038/s41558-020-0797-x>

Lombardy Section Italian Society Infectious And Tropical Diseases (2020) Vademecum for the treatment of people with COVID-19. Edition 2.0, 13 March 2020. Infez Med. 2020;28(2):143-152.

Long Q, Liu B, Deng H et al (2020) Antibody responses to SARS-CoV-2 in patients with COVID-19. Nat Med. <https://doi.org/10.1038/s41591-020-0897-1>

Maturana HR, Varela FJ, Blass B (1980) Autopoiesis and Cognition: The Realization of the Living. D Reidel Pub Co, Boston

Miller C (2020) The Dominance of the U.S. Dollar During the COVID-19 Pandemic. Foreign Policy Research Institute. Available via: <https://www.fpri.org/article/2020/05/the-dominance-of-the-u-s-dollar-during-the-covid-19-pandemic/> Retrieved 6 May 2020

Mizumoto K, Kagaya K, Zarebski A et al (2020) Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan. Eurosurveillance Vol. 25 doi: 10.2807/1560-7917

National Institute of Disaster Management, India (2020) Russia Report. Available via <https://nidm.gov.in/covid19/pdf/covid19/country/Russia.PDF>

[nextquotidiano.it](https://www.nextquotidiano.it) (2020) <https://www.nextquotidiano.it/chi-ha-dimezzato-i-posti-letto-negli-ospedali/> Retrieved 25 March 2020

Norwood C (2020). Most states have issued stay-at-home orders, but enforcement varies widely. PBS. <https://www.pbs.org/newshour/politics/most-states-have-issued-stay-at-home-orders-but-enforcement-varies-widely> Retrieved April 9, 2020

[noticias.uol.com.br](https://noticias.uol.com.br) (2020) Bolsonaro critica Witzel por querer impedir voos para o Rio de Janeiro. Retrieved 20 March 2020

[noticias.uol.com.br](https://noticias.uol.com.br) (2020) Bolsonaro critica imprensa e fechamento de escolas e diz que crise passará. Retrieved 27 March 2020

OECD (2015) OECD Health statistics Available via [https://www.oecd-ilibrary.org/social-issues-migration-health/data/oecd-health-statistics/system-of-health-accounts-health-expenditure-by-function\\_data-00349-en](https://www.oecd-ilibrary.org/social-issues-migration-health/data/oecd-health-statistics/system-of-health-accounts-health-expenditure-by-function_data-00349-en)

Oxford Vaccine Group (2020) Oxford COVID-19 vaccine begins human trial stage. <https://www.ovg.ox.ac.uk/news/oxford-covid-19-vaccine-begins-human-trial-stage> Retrieved 24 April 2020

Park J, Barabási AL (2007) Distribution of node characteristics in complex networks. Proceedings of the National Academy of Sciences Nov 2007, 104 (46) 17916-17920; doi: 10.1073/pnas.0705081104

Pascarella G, Strumia A, Piliego C, et al. (2020) COVID-19 diagnosis and management: a comprehensive review. J Intern Med. 2020;10.1111/joim.13091. doi:10.1111/joim.13091

Posocco L, Diani S (2020) Divided Europe. EU's Disaster and the COVID-19 Pandemic. Preprint doi: 10.13140/RG.2.2.24643.96804/1

Rajkumar RP (2020) COVID-19 and mental health: A review of the existing literature. Asian J Psychiatr. 2020;52:102066. doi:10.1016/j.ajp.2020.102066

Reuters (2020) Italy furious at ECB's Lagarde 'not here to close spreads' comment. <https://www.reuters.com/article/us-ecb-policy-italy-minister/italy-furious-at-ecbs-lagarde-not-here-to-close-spreads-comment-idUSKBN20Z3DW> Retrieved March 27, 2020

Reuters (2020) Factbox: Global economic policy response to coronavirus crisis <https://it.reuters.com/article/businessNews/idUKKBN21E1OE> Retrieved 27 March 2020



Rhodes A, Ferdinande P, Flaatten H, et al. (2012) The variability of critical care bed numbers in Europe. *Intensive Care Medicine*. 38 (10): 1647–1653. doi:10.1007/s00134-012-2627-8. ISSN 1432-1238. PMID 22777516.

Roberton T, Carter ED, Chou VB, et al (2020) Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a modelling study. *Lancet Glob Health*. 2020;10.1016/S2214-109X(20)30229-1. doi:10.1016/S2214-109X(20)30229-1

Roper W (2020) Jobless Claims Surpass 40 Million in 10 Weeks. <https://www.statista.com/chart/21575/jobless-claims-over-30-million/> Retrieved May 28, 2020

[saluteinternazionale.info](http://saluteinternazionale.info) (2014) <https://www.saluteinternazionale.info/2014/09/il-sistema-sanitario-tedesco/> Retrieved 15 September 2014

Sanders JM, Monogue ML, Jodlowski TZ, et al (2020) Pharmacologic Treatments for Coronavirus Disease 2019 (COVID-19): A Review. *JAMA*. 2020;323(18):1824–1836. doi:10.1001/jama.2020.6019

Shukla AM, Archibald LK, Wagle Shukla A, et al (2020) Chloroquine and hydroxychloroquine in the context of COVID-19. *Drugs Context*. 2020;9:2020-4-5. doi:10.7573/dic.2020-4-5

Statista (2020) Number of coronavirus (COVID-19) tests carried out in Europe as of May 21, 2020, by country. <http://statista.com/statistics/1109066/coronavirus-testing-in-europe-by-country/> Retrieved May 23, 2020

Statista.com (2020) Coronavirus global online traffic impact as of April 2020, by industry 2020 <https://www.statista.com/statistics/1105486/coronavirus-traffic-impact-industry/>

Statista.com (2020) Value of COVID-19 fiscal stimulus packages in G20 countries as of May 2020, as a share of GDP <https://www.statista.com/statistics/1107572/covid-19-value-g20-stimulus-packages-share-gdp/>

Statista Mobility Market Outlook – Trend Whitepaper. COVID-19 outbreak has had a major impact on several industries worldwide <https://www.statista.com/study/71360/covid-19/>  
Retrieved May 15, 2020

Tam CF, Cheung KS, Lam S, et al (2020) Impact of coronavirus disease 2019 (COVID-19) outbreak on outcome of myocardial infarction in Hong Kong, China. Catheter Cardiovasc Interv. 2020;10.1002/ccd.28943. doi:10.1002/ccd.28943

Thanh Le T, Andreadakis Z, Kumar A (2020) The COVID-19 vaccine development landscape. Nature Reviews Drug Discovery 19, 305-306

The Guardian (2020) 'Nature is taking back Venice': wildlife returns to tourist-free city' <https://www.theguardian.com/environment/2020/mar/20/nature-is-taking-back-venice-wildlife-returns-to-tourist-free-city>

The Lancet Oncology editorial (2020) COVID-19: global consequences for oncology. Lancet Oncol. 2020;21(4):467. doi:10.1016/S1470-2045(20)30175-3

Tollefson J (2020) How the coronavirus pandemic slashed carbon emissions — in five graphs. Nature 582, 158-159 doi: 10.1038/d41586-020-01497-0

[truenumbers.it](https://www.truenumbers.it) (2020) <https://www.truenumbers.it/coronavirus-terapia-intensiva/> Retrieved 23 April 2020

uc.se (2020) Konkursstatistik. <https://www.uc.se/konkursstatistik/branschstatistik/>

UNESCO (2020) COVID-19 Educational Disruption and Response. Retrieved 28 March 2020

U.S. Department of Labor (2020a) News Release: unemployment insurance weekly claims. Available via <https://www.dol.gov/ui/data.pdf> Retrieved 4 June 2020

U.S. Department of Labor (2020b) Bureau of Labor Statistics. The employment situation Available via <https://www.bls.gov/news.release/pdf/empstat.pdf> Retrieved June 5, 2020

van Doremalen N, Lambe T, Spencer A (2020) ChAdOx1 nCoV-19 vaccination prevents SARS-CoV-2 pneumonia in rhesus macaques. BioRxiv preprint doi: <https://doi.org/10.1101/2020.05.13.093195>

Volz E, Baguelin M, Bhatia S et al (2020) Report 5: Phylogenetic analysis of SARS-CoV-2. Imperial College London COVID-19 Response Team. Available via <https://www.imperial.ac.uk/media/imperial-college/medicine/mrc-gida/2020-02-15-COVID19-Report-5.pdf>

White House (2020) Available via <https://www.whitehouse.gov/articles/15-days-slow-spread/> Retrieved 16 March, 2020

WHO. Novel Coronavirus (COVID-19) Situation (2020) Available via <https://covid19.who.int/>

WHO Director-General's opening remarks at the media briefing on COVID-19. Available via <https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020> Cited 11 March 2020

World Bank (2020) The potential impact of COVID-19 on GDP and Trade - A preliminary assessment Available via <https://openknowledge.worldbank.org/bitstream/handle/10986/33605/The-Potential-Impact-of-COVID-19-on-GDP-and-Trade-A-Preliminary-Assessment.pdf?sequence=1>

Woodyard C (2020). "Q&A: What you need to know about the United Kingdom and Ireland travel ban". USA Today. <https://eu.usatoday.com/story/travel/airline-news/2020/03/16/co->

[ronavirus-uk-ireland-travel-ban-what-know-europe-travel-ban/5060715002/](#)Retrieved April 29, 2020.

Wu Z, McGoogan JM (2020) Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA. 2020;323(13):1239–1242. doi:10.1001/jama.2020.2648

Zehender G, Lai A, Bergna A et al (2020) Genomic characterisation and phylogenetic analysis of SARS-CoV-2 in Italy. Journal of Medical Virology, <https://doi.org/10.1002/jmv.25794>

Zhao Z, Li H, Wu X, et al (2004) Moderate mutation rate in the SARS coronavirus genome and its implications. BMC Evol Biol. 2004;4:21. doi:10.1186/1471-2148-4-21

Zhou P, Yang X, Wang X et al (2020) A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 579, 270–273. <https://doi.org/10.1038/s41586-020-2012-7>