

Research Paper

Knowledge, Attitude and Practice Evidence in Digital Environment and Forecasting the Corona Virus Outbreak in the UK, Spain and Belgium

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Abstract

Purpose: Based on Statista reports as of April 7, 2020, there have been 52,624 deaths in Europe due to COVID-19 since the first recorded European death in France on February 15. **Method:** We compared two models to assess the outbreak of coronavirus in the UK, Spain and Belgium, their healthcare expenditure and the number of hospital beds as two indices of the healthcare system. Base and advance exponential smoothing models were used to forecast the total number of new cases and fatalities in the next 15 days for each of the evaluated countries, with an upper and lower banding. **Findings:** The models were fine-tuned with temporal granularity and an adjust seasonality set to seven days. Furthermore, the study assessed the healthcare capacity of these countries by looking at key metrics at a national level and tried to compare them in a relative term by drawing correlations between the total number of cases and fatalities. In addition, the current study compared the three countries according to the KNOWLEDGE, ATTITUDE and PRACTICE (KAP) system and found the associated similarities. Also, the gaps in KAP on WHO level was appraised. **Conclusion:** The KAP shortfalls at all levels of international, governmental, organizational and individual levels were recognized. The success of the implementation of any intervention in the prevention of coronavirus epidemics is highly dependent on KAP of people, organizations and governments. Finally, a multicomponent system at international level is proposed to tackle the future infectious pandemics.

Keywords: Corona virus, Outbreak, KAP, WHO, The UK, Spain, Belgium.

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Introduction

Coronaviruses are a large family of viruses, ranging from the common cold virus to more serious diseases such as SARS, Mers, and COVID-19 (Tyrrell and Bynoe,1965; Visy and et all, 1991). The virus naturally spreads to mammals and birds, but seven human-transmitted coronaviruses have been discovered up to now. The virus has infected more than 200 countries worldwide and has killed about 200,000 people so far. The recorded deadliest day in EU has been April 4th, 2020 with 5,186 fatalities in 39 countries (Number of coronavirus (COVID-19) deaths in Europe, 2020). Solving the humanitarian challenge with appropriate preventive measures such as vaccine development is the top priority for the current pandemic (Hua and Shaw,2020 ; Coronavirus Live Updates, 2020). Countries approached differently to deal with the disease. Quarantine, border controls, school closures and a ban on rallies were among the measures taken to prevent the spread of coronavirus in European countries. Epidemiologists believed that the COVID-19 outbreak could not be stopped, but implementation of preventive measures and physical distancing could prevent an unmanageable peak of cases. These measures depend on the correct knowledge, attitude and practice (KAP) of people, organizations and governments about the virus and outbreak. A poor level of KNOWLEDGE has been implicated in the rapid spread of the infection in society. The higher the correct information (KNOWLEDGE) about coronavirus and its behavior and outcomes, the higher the correct concern (ATTITUDES) about it, and the more likely people will be engaged in protective measures (PRACTICES). KAP research framework has been widely used in public health, and as a guide of health education for behavioral changes (Jaccard, Dittus and Gordon, 1996). "K" means awareness of the problem or disease. "A" stands for the attitude towards the problem or disease. "P" represents exercise or preventive behaviors to protect against the problem or disease. Researchers believe that KNOWLEDGE, ATTITUDES, and PRACTICE are inter-related (Rav-Marathe, Wan and, Marathe, 2016). There is a two-way relationship between KNOWLEDGE and ATTITUDES, ATTITUDES and PRACTICE, and KNOWLEDGE and PRACTICE. But being aware of health behaviors that are beneficial, does not automatically mean they will follow these behaviors. ATTITUDES

are not directly observed and are difficult to measure (Schwartz, 1976).

Many studies have examined various levels of KAP about infectious outbreaks, such as SARS, avian Influenza (Deng and et al, 2006; Di and et al, 2008) and H1N1 (Rubin and et al 2009; Effler and et al. , 2009). The current COVID19 pandemic has affected all countries in economic, social and psychological terms, as well as international relations. The rapidly spreading virus imposed a heavy burden on national health care systems, as they lack the adequate resources and manpower to respond to the growing number of patients in need of intensive care (Jin and et al, 2020; Dong Du and Gardner, 2020; Chen and et al. 2020). Therefore, it is necessary to develop a model to predict the outbreak of coronavirus and to design a strategy to battle this global pandemic. In this study, we built a predictive model based on the cumulative trends of new cases and deaths for the UK, Spain and Belgium. We also looked at modeling the trends for confirmed cases and deaths for these countries. We used the number of hospital beds and the annual health budgets to roughly compare the current preparedness of countries to fight coronavirus outbreak. Then, using the KAP framework, we discussed the role of shortcomings in preventing the spread of this disease in these three countries. We also evaluated the deficits in leadership role of WHO in preventive measures of current pandemic.

Method

Datasets

The COVID-19 datasets are derived from the World Health Organization, WHO situation report. Datasets which contain the total number of confirmed cases and fatalities are used in the predictive modelling for each country starting on March 1 to April 2, 2020.

Modelling

Exponential smoothing models iteratively forecast future values of a regular time series of values from weighted averages of past values of the series. The simple exponential smoothing model was applied to the base model, which computed the next smoothed value from a weighted average of the last actual value and the last level value. The method was exponential because the value of each level was influenced by every preceding actual value to an exponential

decreasing degree. More recent values were given greater weight. An advance predictive model was created by adding new components like trend and seasonality to the base model. Trend was a tendency in the data to increase or decrease over time. Seasonality was a repeating, predictive variation in value. Out of the four trend analysis models, linear, logarithmic, exponential and polynomial, the most suitable were applied. Due to relatively small dataset, the temporal granularity was set on a daily scale and the seasonal length set at 7 days. This means the length natural to the temporal granularity was used to construct the seasonal exponential smoothing model to support his assessment. The AIC of the seasonal models and the three non-seasonal models were compared and the lowest was returned as the best predictive model. Both the base model and the advance model were tested against the five regression model evaluation methods as discussed below.

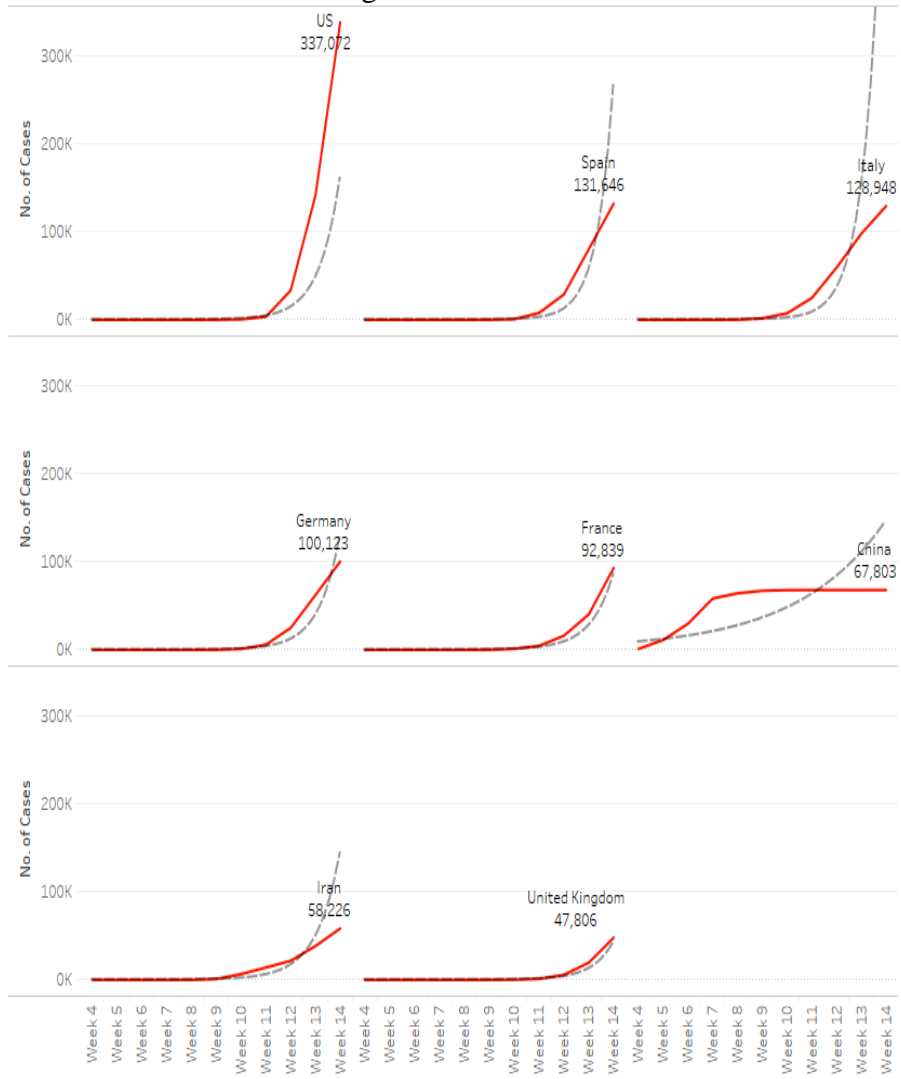
Regression Model Evaluation

MAE refers to mean absolute error. It gives less weight to outliers, in order not to be sensitive to outliers. MAPE refers to mean absolute percentage error. It is similar to MAE but normalized by true observation. Its downside is when the true observation is zero, which will be problematic. MSE refers to mean squared error. MSE is like a combined measurement of bias and variance of the predictions; i.e., $MSE = Bias^2 + Variance$. RMSE refers to root MSE. It takes a root of MSE and bring the unit back to the actual size, and it makes it easy to interpret the model accuracy. It is basically the standard deviation of the residuals (prediction errors). Residuals are a measure of how far from the regression line data points are. Both the MAE and RMSE can range from 0 to ∞ . They are negatively oriented scores, which means lower values are better. AIC, Akaike information criterion, tests how well the model fits the data set without over-fitting it. The AIC score rewards the models that achieve a high goodness-of-fit score and penalizes them if they become overly complex. A lower AIC score indicates a better fit.

Results

Predictive modelling was performed on the dataset from Spain, Belgium and the United Kingdom since these European countries have similar healthcare standards, culture and political structure. A

high-level over-view of the number of confirmed COVID-19 cases and fatalities are shown in Figure 1.



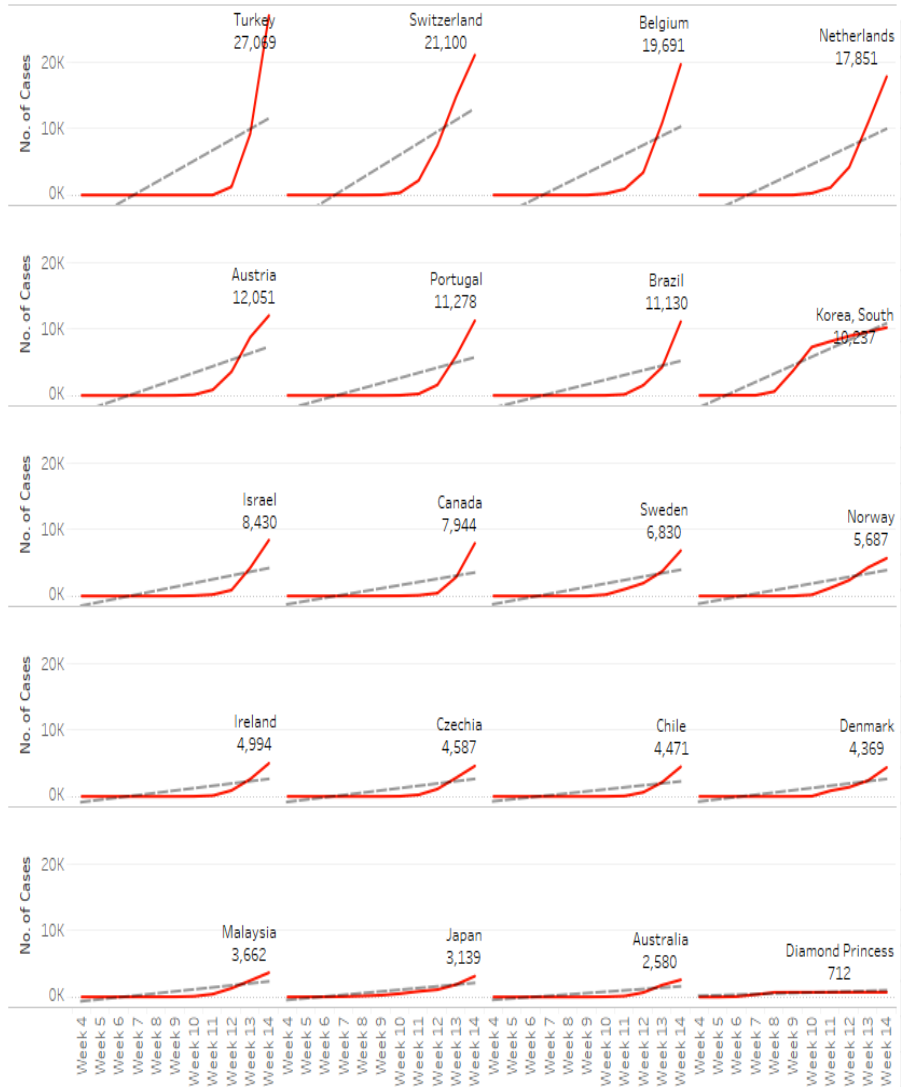


Figure 1. Countries ranked by the number of confirmed COVID-19 cases by 5th April, 2020; A: those with over 40K; B: Those between 700 to 40K.

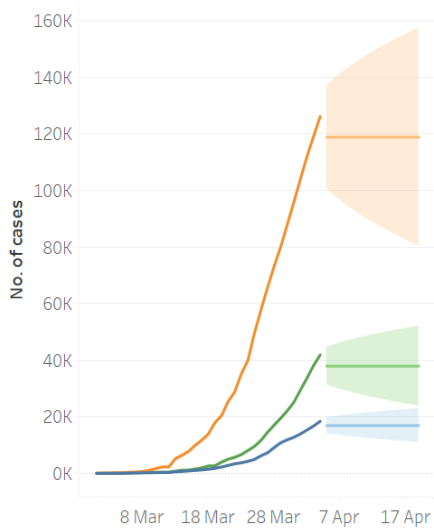
Outputs from the base and advance predictive model for Spain, Belgium and the United Kingdom are shown in Figure 2, where the model outputs are numbers of confirmed cases and fatalities. The base model adopts a simple-exponential-smoothing model, expanding on the time-series based on the historical weighted average daily values

to generate a forecast of 15 days ahead. The advance predictive model adopts exponential smoothing with an additive trend and additive seasonality to produce a more representative forecast.

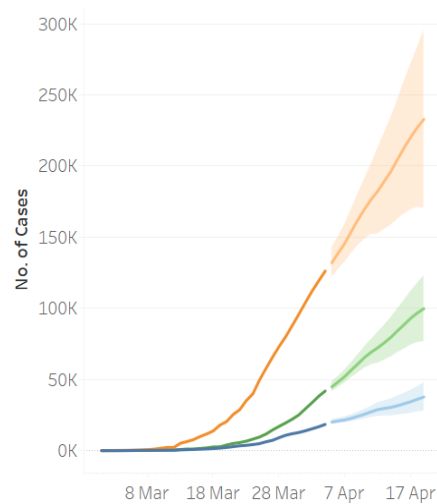
A.

- Country/Region, Forecast indicator
- Belgium, Actual
- Belgium, Estimate
- Spain, Actual
- Spain, Estimate
- United Kingdom, Actual
- United Kingdom, Estimate

Base modelling of new number of cases



Advance Predictive Modelling of new number of cases



B.

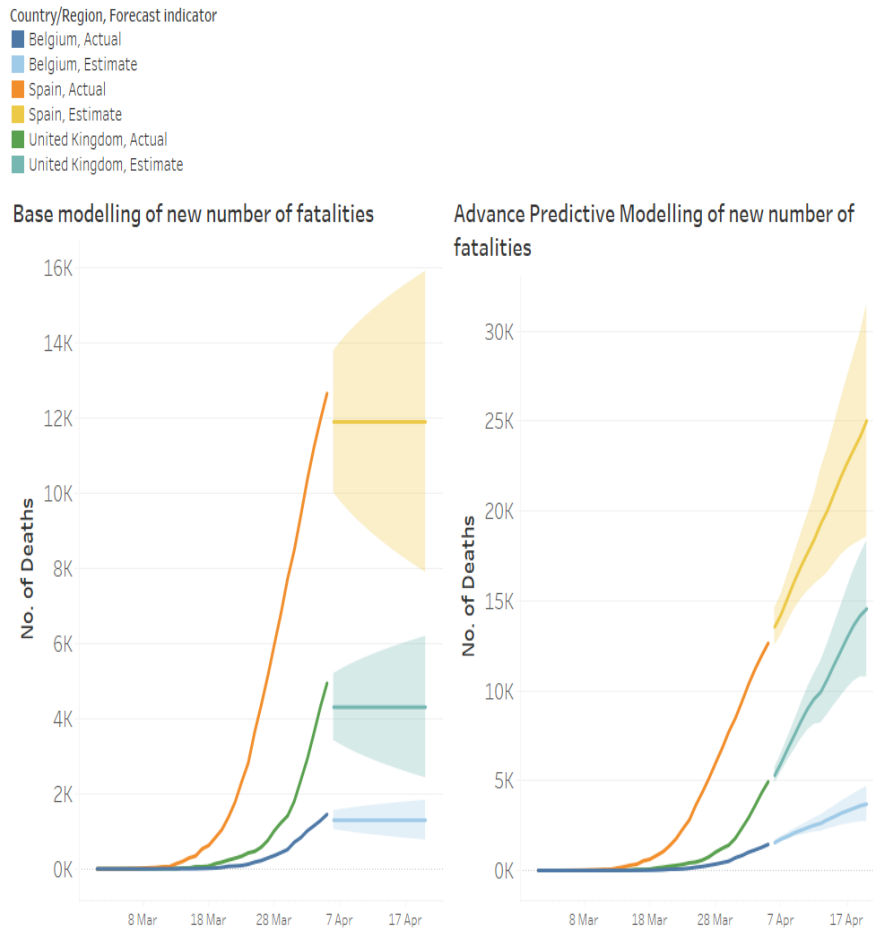


Figure 2. A comparison of the base and advance predictive modelling of the new number of confirmed cases (A) and fatalities (B) across Spain, Belgium and the United Kingdom (15 days ahead from 5th April 2020).

Root mean square error (RMSE) of the base case model for Spain, Belgium & the UK was 3403, 9265 and 1426, respectively. In comparison, RMSE in advance predictive case model was 1793, 5317 and 858, respectively, which indicated the absolute fit of the advance model is significantly better. RMSE of the base fatalities model for Spain, Belgium & the UK was 452, 963 and 127, respectively. In comparison, RMSE in advance predictive fatalities model was 220, 557 and 62, respectively, which indicated the absolute fit of the

advance model is significantly better. Akaike's information criteria (AIC) of the base cases model for Spain, Belgium & the UK was 575, 645 and 514, respectively. In comparison, AIC in the advance predictive model was 548, 625 and 497, respectively, which indicated again the advance case model has the most parsimonious fit, and a higher likelihood of the forecast. AIC of the base fatalities model for Spain, Belgium & the UK was 446, 501 and 355, respectively. In comparison, AIC in the advance predictive fatalities model was 412, 475 and 321, respectively, which indicated again the advance fatalities model has the most parsimonious fit, and a higher likelihood of the forecast. The advance model forecasted that across all three countries, the total number of cases would likely be doubled by 19th April 2020, with a lower and upper limit of 170K-290K for Spain, 80K-120K for the UK and 35K-50K for Belgium. The UK has the highest population with 69 million inhabitants which is 20 million more than that in Spain and 6 times higher than that in Belgium. The UK had the lowest relative number of cases and fatalities per million population out of the three countries (Spain: 2800 cases/million, and 282 fatalities/million, Belgium: 1780 cases/million and 140 fatalities/million, and the UK: 665 cases/million and 77 fatalities/million).

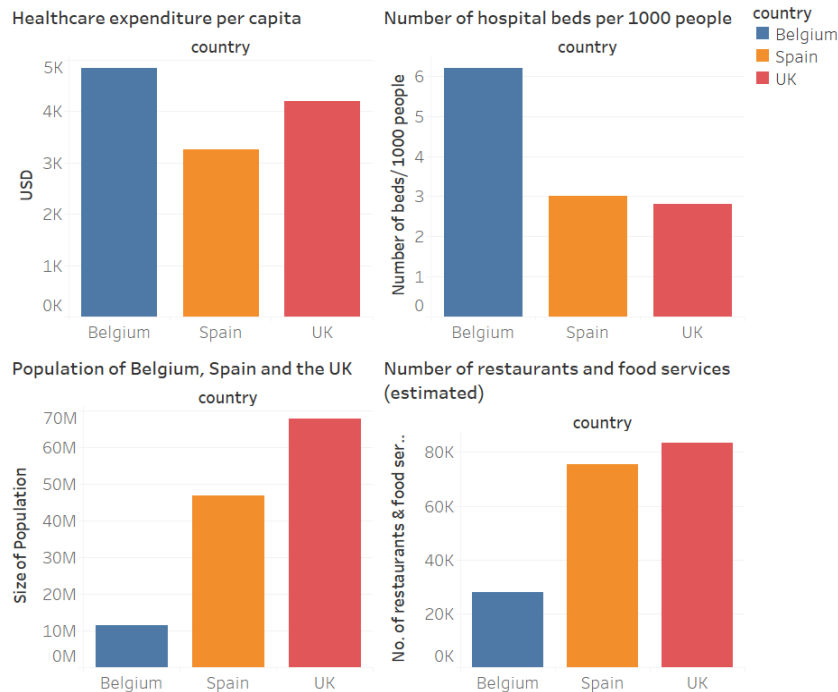


Figure 3. Social-economic metrics relevant to the COVID-19 outbreak study

On the other hand, Belgium has two times higher number of hospital beds per 1000 people compared to Spain and the UK. Also, Belgium has the highest annual expenditure per capita out of the group, yet the number of fatalities is higher than that in the UK by a factor of 2. This seems even stranger when we know the total number of local hotspots for potential COVID-19 transmissions, like restaurants and foodservice outlets, is 2.5 times lower in Belgium compared to Spain and the UK. Spain has seen an earlier onset of COVID-19 fatalities compared to the UK and Belgium, which has resulted in 2.5 times and 6 times higher number of fatalities, respectively, even though, geographically, these countries are considered close (Figure 3).

Discussion

The predictive model showed the capability to handle short-term predictions for various countries in Europe. The upper and the lower error bands will increase as the length of forecast increase and can be

corrected when more COVID-19 data is available to adjust the multiple parameters. Comparisons can be made to the classic models such as SEIR. History has shown that people's behavior in fighting infectious diseases plays an important role in preventing the pandemics (The Conversation. Coronavirus: why changing human behavior..., 2020). During the 1918-1919 flu epidemic, behavioral factors such as the abolition of large gatherings, physical distancing, and simple hand washing helped slow the spread of disease. The greatest preventive measures in tackling 1918 flu pandemic in the UK were school closure and people's behavioral changes (Lister and Rebaza,2020). According to the World Health Organization, behavioral changes can reduce the virus spread by up to 80% (WHO,2008). Research has also shown that human behavior modifications since 2003 has played an important role in managing the Ebola outbreak in 2001-2002 in Uganda (Hewlett and Amolat, 2003). Therefore, it is necessary to examine the behaviors, beliefs and actions of the people, organizations and the governments in this crisis. The higher prevalence of the disease could be rooted in the wrong lifestyle, misconceptions, or misbehavior between the people, organizations and the governments. Reviews of various websites and news agencies suggest several similar evidences of violations of preventive measures in the UK, Spain and Belgium. Examples are given below.

KAP Evidence in Spain

The first case of the disease in Spain was reported on January 31st. In late February and early March, the Spanish government issued no serious warning that the disease was dangerous. The leading epidemiologist of the Spanish government said in late January that Spain probably "wouldn't have more than a few cases." In late February, a critical moment in the virus' spread across the country, he told the press that "the virus isn't in Spain." These were clear examples of lack of enough KNOWLEDGE by the government. Obviously, the government didn't forecast imminent threat. Soccer matches, social gatherings and political rallies were not stopped. Medical equipment, specialized tests, and facilities needed to detect and deal with epidemic were not prepared. Spain failed to detect an outbreak in the first few weeks. These were unfortunate examples of negligence and inappropriate PRACTICE by the government.

Consequent lack of enough masks, gloves and gowns brought a higher level of risk for health professionals, and the consequent lack of enough sanitary materials exacerbated the speed of virus spread among the public. On March the 8th, International Women's Day, while the disease was in critical condition, the Spanish government called on people to demonstrate on International Women's Day, which in turn spread the virus among the people. This was another example of improper PRACTICE by government. The first lady and three ministers of cabinet were diagnosed with COVID-19 few days after International Women's Day. This was an example of improper ATTITUDE by the government. By the time the government asked people stay home, people's historical paranoia to long term dictatorship in Spain, enjoying unexpected holiday by coming to the streets leading to more congestion, late-night culture in Spain, and finally, the belief that this is a problem elsewhere helped the virus spread more easily. These illustrated people's wrong ATTITUDES in appraising the imminent danger of infectious epidemics in Spain. By the time COVID19 patients were to die, people started to BELIEVE the depth of threat. That was too late. By March the 13th, when Spanish Prime Minister declared the state of alarm, virus did spread almost everywhere through the chains of improper KAPs by government and people (McMurtry and Zampano,2020; Ward,2020; Perez Maestro and et all. 2020; Fotheringham, 2020;Aguado and Allen, 2020).

KAP Evidence in Belgium

Lack of appropriate KAP was also the main issue in Belgium. The Belgian government underestimated the risk of epidemic even when the virus did spread all over Italy in late February. Carnivals were allowed to proceed in many cities at the end of February (wrong ATTITUDE). On March 3rd, the government's scientific committee predicted that in the worst-case scenario, the virus will infect 13,000 people, of which 2,000-3,000 will be hospitalized, and 500-700 will need intensive care unit (ICU). This means the government had no accurate KNOWLEDGE about the epidemics. Accordingly, the government didn't implement wide screening, didn't prepare enough protective masks, face shields and respirators to deal with epidemics and, also other preventive measures were minimal. On March 4th, the Flemish Agency for Care and Health advised schools to stay open.

These were solid examples of negligence and inappropriate PRACTICE by the government. At the same time, a few mayors knew that the federal measures were insufficient and banned all outdoor and indoor activities in their municipalities. Eight days later, on March 12th, the government issued an order for closure of schools, cafes, discos and restaurants, but people were not required to stay home. On the other hand, Belgian people went skiing in Italy during school holiday (February the 22nd till March the 1st). This was an example of improper ATTITUDE by people. In a research study carried out in a 10-day period of March 23rd to April 3rd, it was shown that about 85% of companies did not follow the preventive measure of physical distancing. In another study, it was recorded that younger generations were less likely willing to follow the physical distancing rules. These were again few examples of wrong PRACTICE by people. By March 18th, when Belgian government ordered the mandatory physical distancing at the national level, virus did spread almost everywhere through the chains of improper KAPs by government and people. If the government had the correct KNOWLEDGE and ATTITUDE, their prediction based on the situation in Italy would have been closer to the realities and would have been started the correct PRACTICES of preventive measures 3-8 weeks earlier (Bradshaw, 2020; coronavirus pandemic in Belgium, 2020).

KAP Evidence in the UK

More than a month after the first COVID-19 case was approved in the UK, the government declared for preparation against significant expansion of virus among the UK population. On March 13th, the UK chief scientific adviser told the press that the key in this epidemic is to build up the herd immunity to cut viral transmission. The government believed that 60% of people should be infected in order to have the herd immunity. Obviously, by having this KNOWLEDGE and the corresponding ATTITUDE as the right approach by the government, the required medical equipment, specialized tests, and facilities needed to detect and deal with epidemic would not be prepared. The UK failed to detect an outbreak in the first few weeks. Consequent lack of enough masks, gloves and gowns brought a higher level of risk for health professionals, and the consequent lack of enough sanitary materials exacerbated the speed of virus spread among the public (negligence and MALPRACTICE). More than 200 scientists and

researchers called on the government to reconsider this view, as the herd's immunity will pollute millions of people. Lack of accurate government statistics on the exact number of patients showed another weakness in PRACTICE. Despite the outbreak of coronavirus, a major march took place on March 8th in London. On March 22nd, the government announced that 1.5 million people who are infected with the virus would be isolated for 12 weeks. Despite heavy fines and court actions for those opposed to physical distancing, it was observed that some people broke the rules and ignored the warning. They were out to the parks with their families to enjoy the warm weather. A poll claimed that only 23% of British adults followed the government's recommendations. Also, incidents of racism were recorded. These examples indicated the wrong ATTITUDE and the wrong PRACTICE by people (Booth, 2020; Coronavirus: Are people ignoring social distancing advice?, 2020) 60% of UK population need to get coronavirus so country can build 'herd immunity', 2020; Mueller, 2020; Boyle, 2020; Boris Johnson's coronavirus adviser calls for a way out of lockdown,2020; Alwan and et al. 2020; Cellan-Jones, 2020; Evening Standard, 2020; Roberts, 2020; International Women's Day, 2020; Fidler, 2020; Tominey, 2020; Campbell, 2020; Coronavirus: Men wanted over racist, 2020).

KAP Evidence in World Health Organization (WHO)

The current COVID19 is not the first world pandemic and won't be the last one. What have we learned in terms of KAP from the previous ones? The following paragraphs present valid questions that underlie the elements of an appropriate multi-component system to appropriately and timely deal with a pandemic.

Who is the leader of the world public health? What is the role of the leader? Who should have been forecasted the upcoming pandemic? Who must have predicted the unforeseen threats of a possible pandemic? Who must have warned the world far in advance about the requirements for an upcoming pandemic? Who must have prioritized the necessities in advance? The upcoming pandemic, the unforeseen threats, the requirements and the priorities all could have been incorporated in epidemiological games for public. Who could have produced these games to educate people about the history of pandemics and prepare their mentalities for preventive responsibilities in future pandemics? Epidemiological game would inject the required

KONWLEDGE, the appropriate ATTITUDE and the right and step by step PRACTICE to do their individual roles in order to keep themselves, their families, their coworkers and their communities as safe as possible during epidemics.

Who should have carefully monitored the transparency of data? Are people given the right to be aware of the true risk of contagiousness and mortality? Who should have worked towards minimizing the health care inequalities among the countries before and during infectious pandemics? What will happen if the next viral outbreak is ten times more severe than the current COVID-19 in terms of contagiousness and mortality and starts from a poor country? Who should immediately identify the risk and help the poor country to recognize and prevent the infection from spreading? Who should have set up the international collaborations beforehand for immediate and advanced developments such as the developing the diagnostic kits? Who should have established the international collaborations among the world key laboratories in advance to produce the proper vaccines quickly? Who should have previously developed the international collaborations among various pharmaceutical companies for immediate mass production of vaccines after its development? All the above-mentioned issues are elements of a practical and efficient multi-component system that could have been set up, years in advance, and tested and improved every year. Who must have prepared this practical system to deal with the possible pandemic? Who should have tested the proposed multi-component system against time to understand possible shortcomings and unforeseen requirements? Who should have verified the multi-component system in collaboration with different countries in five continents to unfold limitations? Who should have tried out the multi-component system in mutual maneuvers with army forces to disclose the weaknesses? Who should have developed the required software's to run the practical system? The Examples of such softwares are the ones using satellite and cell phones for locating the patients in interactive maps for public to control their physical distancing or the software that will help people find the best associated resources. The COVID-19 disease was first identified in December 2019. If there was such a strong and prepared multi-component system explained above, the discovery of the first case could have turned on the whole system immediately.

Conclusion

It seems the current COVID-19 pandemic crisis and its high mortality is the result of all the above-mentioned issues at international, governmental, organizational and individual levels. Each level must be armed with the correct KAP associated with true leadership and transparency in order to properly accomplish its mission (Figure 4).



Figure 4. A conceptual framework of the Knowledge, Attitude, and Practice

Figure 4. A conceptual framework of the Knowledge, Attitude, and Practice integrated by the elements of multi-component system explained above. Collaboration at all levels of international, governmental, organizational and public is needed to overcome the pandemic crisis.

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