Analyze National and Global Emergency Responses to the COVID-19 Pandemic through the Quality Lens and Data Driven Approach of the Lean Six Sigma

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Abstract

This paper aims to analyze some of the main issues surrounding the national and global emergency responses to the COVID-19 pandemic through the quality lens and data driven approach of the Lean Six Sigma Define Measure Analyze Improve Control (DMIAC) methodology. The novel coronavirus (COVID-19) is a newly observed respiratory illness that began to spread at alarming rates in Wuhan, China. Currently, there is not a vaccination or treatment. Our focus is on the Emergency Preparedness Response for the US Health Departments and global health authorities. During this pandemic, the Critical to Quality (CTQ) indicators are: real time communication, supplies and professional protective equipment availability and rapid recognition surveillance. US government supply chain relief effort rely on established memorandum of agreement and understanding. Supply Chain for humanitarian missions have many levels of complexities but is proven effective.

Keywords
COVID-19, Emergency, Preparedness, Health Department, Communications.

Arguments and Claims
Based on an estimated average COVID-19 hospitalized patient, the treatment for non ICU is $11,050 and for ICU it is $30,950 per person. Delays in communication seem to negatively impact confirmed cases and death. The inability to define a definitive case hindered the prevention and treatment efforts of the CDC and health departments. Lag response times to a worldwide pandemic can worsen health care issues in economic and socially vulnerable regions. The pandemic began during the seasonal influenza outbreak, therefore the testing supplies were depleted. Symptoms are similar for both and so is testing. In the event of emergencies, hospital medical supply deliveries can be severely delayed.

The Methodology
Lean Six Sigma is a data driven problem solving method that focus on reducing delays, deviations, and defects. Six Sigma's Define Measure Analyze Improve and Control (DMAIC) was followed for this project. Team members adhered to the stay-at-home mandate by state governments and one team member was actively working on the front-lines to test and aid patients, therefore the research and data was taken from the website along with quality resources. Data and situations were highly volatile which cannot be compared to data in corporate under normal circumstances.

Define
The "Define," phase helped us understand the project, problem, stakeholders, customers, financial impact, scope and size and other details. SF Consultant Team began with a project charter along with the IEOM's requirements which helped us remain focus on the goals (see Appendix A). Then we completed a SIPOC, CTQ Tree and Process Map to gain additional information. The Project Charter effectively helped identify the problem statement. We used the Transfer Function, Y=f(x) or Y=f(x1, x2, x3….) to determine the key components of Y. Y=Output which is the problem and X=the contributing factors. There were many contributing factors so we weighed the factors and selected the highest impacts. Emergency response preparedness is the problem and the contributors of interest are: communications, supplies and personal protective equipment, and surveillance. The Problem statement describes the

problem being solved by the project. It also reveals the critical pain of the situation and validates the need for the project.[1]

Problem Statement

Communication issues resulted in a lag for the response time for many health departments and global health authorities. Delays with the acquisition of testing supplies caused community wide-spread infections, 895,766 confirmed cases and total deaths 50,439. Supplies and professional protective equipment (PPE) were delayed for front-line health care providers and responders. Heath Care Workers were exposed and infected and some have lost their lives. Originally, COVID-19 was not added to the statewide surveillance system, therefore states could not account for confirmed cases. Identifying clusters to stop the spread of infection was a challenge.

Six Sigma Tools for Define

The SIPOC enabled the identification of suppliers, input/enablers, process in detail, output, and the customers. Key Process Input Variables (KPIV) and the Key Process Output Variables (KPOV) were included on the SIPOC. These variables proved important to the test process for confirmed cases of COVID-19 at the health department. The Critical to Quality (CTQ) tree shows the customer, critical to quality factors and the measures for each quality. The health department is the customer who expects to achieve emergency response readiness. They also need medical supplies and adequate PPE. Finally, effective surveillance which enables rapid recognition of the disease is required to confirm cases of COVID-19 timely. Measures are: Responds Rate, Inventory Accuracy, Delivery Rate, and Surveillance Recognition Rate. The Process Map shows how the health department obtains medical supplies. Apparently, supplies were used for the influenza shortly before the rapid spread of COVID-19. Looking through the Lean lens there was no waste identified in this process.

DEFINE

SF CONSULTANT Team: C. Floyd, S. Floyd

S I P O C for the Health Department

Constraints: None

Begins With: Accurate Triage Reporting

KPIV

Ends With: Accurate test results

KPOV

Process/Activities: 1) Call on phone and get triaged for symptoms, 2) if symptoms meet criteria then a doctors' appointment is made, 3) Patient arrives at the entrance of the Health Department to get temperature checked, 4) they go the back of the building to see the doctor and get tested, 5) Laboratory COVID19 Rapid Tests, 6) Physician gives results to patient

Inputs: Patients providehealth condition

Outputs: 1) Test results given by Physician, 2) Patient is directed to quarantine for 14 days, 3) Patients are referred to hospital as needed.

Supplier(s): McKesson-Medical Supplies, Indian Health Services-Medical Supplies, Center of Disease Control-Initial Notification for pandemic, State-Information (i.e. vital records, resources required, lab work), County-distribution for materials and supplies, National Stockpile

Customers: US Health Department, Global – Health Authority Surveillance, Guidance, Facilitate Planning for the Pandemic

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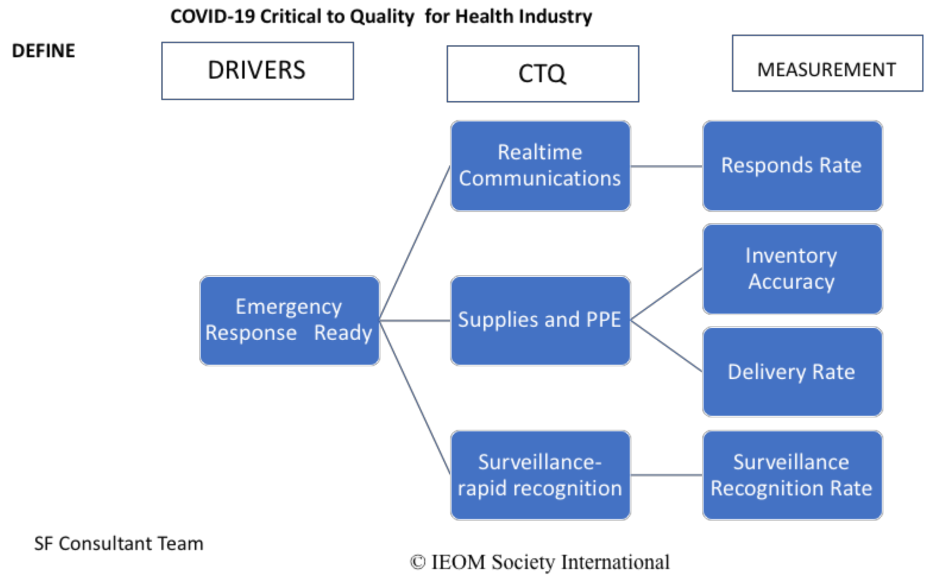
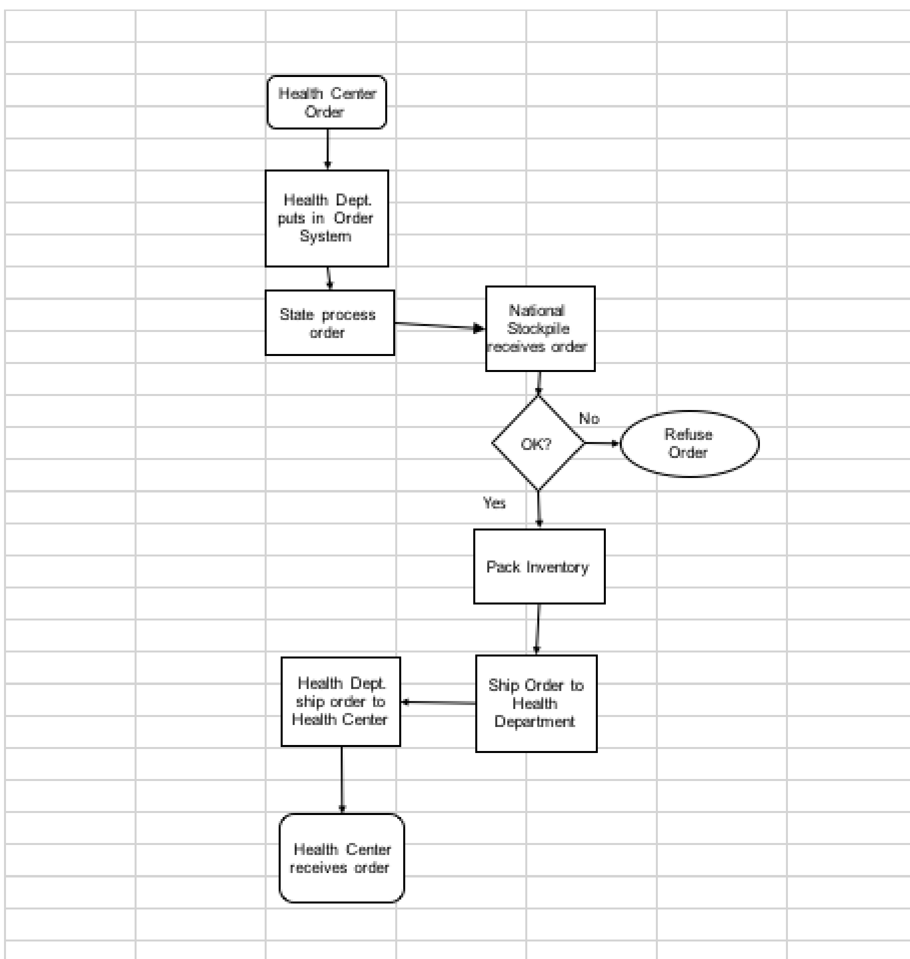
[1] Hansen, M. Lean Six Sigma The StatStuff Way, 1st Edition, Essentials Publishing, 2013



COVID-19 Medical Supplies Map



Measure

The "Measure," phase determines the research strategy which includes the appropriate data collection method. We also collected data based on the key x's from the transfer function. Some team members found continuous data on-line. The health department's database consisted of attribute data with many metrics about confirmed cases, deaths and testing on a daily basis. Furthermore, excellent sources of international data was available at the World Health Organization's (WHO) website and Statistica.com. These global resources with US CDC and the health departments were very reliable.

Six Sigma Tool for Measure

MSA-Test for Accuracy, Precision, Sensitivity, and Reproducibility

Though highly volatile, confirmed case total, fatality total, and other information was tested by referencing each website at the same moment to compare numbers. The WHO, CDC, Statistica.com and the US Health Department's data confirmed cases, statistics, and status reports were reproducible for the COVID-19. [2]

The Measurement System Analysis has a formula to measure Effective % = Number of people/Total number of people. We could ask the question, "What would be a good number of people who are healthy to open full operations?" We could get the number of confirmed positive cases/Total Population by State and get a number. Everybody in the state has not been tested for COVID-19 and the disease is highly contagious, therefore, an alpha or beta risk factor may not apply to this situation. However, the effective rate could apply to predict when a state should reopen businesses.

Example A small state in the US is deciding when to reopen the businesses to get people back to work. It's effective rate for 83%.

$$\frac{99{,}850{,}000 \text{ Confirmed negative cases}}{139{,}649{,}000 \text{ Total population}}$$

Since the state has a 72% effective rate it may be possible to allow businesses that offer services with social distancing of 6 feet. Businesses that offer services with personal contact (i.e. spas, beautiful salons, barber shops, etc.) should not be opened at this time.

Analyze

One of the most critical components of emergency medical preparedness for a regional pandemic is the ability to leverage robust scientific insights in a way that can optimize logistics lead times- thus providing adequate time for preparation to meet supply chain needs. Furthermore, utilizing statistical tools to bridge any communication gaps between medical and logistics professionals within a regional health department allows for a smoother and effective coordination process. This analysis will first observe the significant impact that lagged response times and coordination within State Departments of the US have on citizens as well as the overall health industry within those states. Second, this analysis will identify some ways in which predictive analytics and optimization models within statistics serve as beneficial tools for emergency preparedness within the medical, logistics, and supply chain sectors of a Health department.

When observing the possible effects that an outbreak can have in one region, coordination and communication between epidemiologists and health professionals is pertinent to the initial emergency response planning process. During the early stages of pandemics, scientists and epidemiologists play vital roles in detecting and identifying the signs of an outbreak, and then further coupling surveillance techniques and the utilization of statistical tools to predict how the target disease can spread in other regions of close proximity. First, understanding and communicating the risk of infection and the ability to spread is important in illustrating the potential impacts of the target disease and furthermore, communicating the need to accelerate or prioritize an effective emergency medical response strategy for the coming periods. Utilizing probabilistic models to calculate the chance that an outbreak will occur by showing the probability that an individual will get infected and then the probability that the infected will spread the disease (Liao et.al, 2017).

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[2] Oke, J., Heneghan, C., COVID-10 Case Fatality Rates, Available: https://www.cebm.net/covid-19/global-covid-19-case-fatality-rates/, March 17, 2020; Michigan Department of Health, https://www.michigan.gov/coronavirus/; Statista, Number of Coronavirus cases worldwide, https://www.statista.com/statistics/1043366/novel-coronavirus-2019ncov-cases-worldwide-by-country/,; CDC, Pandemic Influenza Plan – 2017 Update, https://www.cdc.gov/flu/pandemic-resources/pdf/pan-flu-report-2017v2.pdf

Second, after displaying the risk of an outbreak, predictive analysis tools are used to calculate how fast the target disease can spread throughout a region. The scientific industry has a variety of ways to predict the case increase of an outbreak; however, regression analysis has shown to be the foundation of the many of these models. Once a solid process for predicting the spread of the outbreak is established, communication between health department officials, analysts, and the supply chain sectors of the health department should occur in order to ensure that a supply chain system is in place that will accommodate the future needs surrounding medical supplies and other essential items.

A Need to Understand Risk

One of the first steps in providing clear communication between epidemiologists and health department workers is to calculate and express the risk involved in an outbreak event in a target country. When observing and identifying inter-country transmission risks, the epidemiologist should find out the probability of an epidemic transmitting to a country. To do this, we first establish the probability that someone who has the disease is in the infected country and may be travelling out of the country. In the case of Wuhan, China, the first confirmed case was January 5, 2020. The World Health Organization (WHO) report stated that there was an initial number of 44 people in Wuhan with 121 identified close contacts (WHO,2020). This means that they were in the initial stages of the outbreak in China. Possibly, in January, there were 165 people who had the novel coronavirus which at the time was identified as pneumonia. At the time, the proportion of possible cases (165) to the population of Wuhan, China (close to 19 million) was negligible in terms of raising alert regarding the illness. However, a little over two weeks later on January 22, 2020, it was announced that transmission was occurring during surveillance measures at the Wuhan Airport (WHO, 2020). Given that these cases displayed symptoms of flu or pneumonia and can be transmitted through human interaction, we can observe three time periods with a certain known amount of cases and use the assumption that there is a fixed population number. A classical Bayesian probability method can calculate the number of target observations divided by the total sample size of your data to show the probability of a person contracting and spreading COVID-19 in Wuhan, China. Table 1 takes three known data points for known cases and contact points identified in Wuhan during the early onset of the COVID outbreak and applies some scenarios to show how fast COVID can transmit in an environment.

Table 1. Actual and Estimated COVID cases in Wuhan China (red is estimated)

Date	Day from January 3, 2020	Number of known cases	Known Contact points	If each contact point had the virus and interacted with 12 people (EST)	Number of total Possible cases	Probability of catching the disease in Wuhan
3-Jan	0	44	121	1452	1617	0.0%
1/23/2020	19	557	765	9180	10502	0.1%
1/30/2020	26	7736	92832	1113984	1214552	6.4%

If we start with the number of known cases, we can already see a significant increase in the region. We can also see a significant increase in the amount of contact points that the known cases have reported. To provide insight on the transmission risk, we used the finding that a person can have an average of 12 interactions per day (Zhaoyang,2018) to apply an increase factor for transmission. For example, on January 30, 2020, there were 7,736 known cases in Wuhan. If each of those cases came in contact with only 12 other people, the number of contact points would be close to 100,000. This is just a basic use of probability that shows the potential risk involved with an outbreak that can be transmitted through human interaction- and it must be noted that the assumptions for this particular calculation method are enormously strong and may not be able to hold when looking at larger countries, but it can provide a quick glance at the potential for an outbreak and the possible mathematical patterns when conducting prediction analyses for short and long term periods.

The next level of analysis should be looking at the conditional probability that someone who is infected, or has been a contact point of someone infected, could be an American traveler planning to travel back to the United States. Scientists can find this probability using a series of conditional probability calculations that factor in the possible indicators that may have an effect on the risk of transmission, such as the geographic proximity of the source region to the possible target region, possible human interaction variables and high risk touchpoints that could result in quick transmission of a disease. A helpful online tool that calibrates many of the aforementioned factors in a risk assessment number that demonstrates the probability of cross national transmission is EpiRisk. The EpiRisk calculation tool factors in variables such as the Population, Number of Infected Cases, travel restriction levels and the amount of time it takes to see the symptoms. If we input an example source country, we can start with Wuhan that had a certain amount of cases (7736) during the January travel month, along with a 2 day window until a symptom shows. Figure 2 shows the probability of a disease traveling from China to various countries of the world.

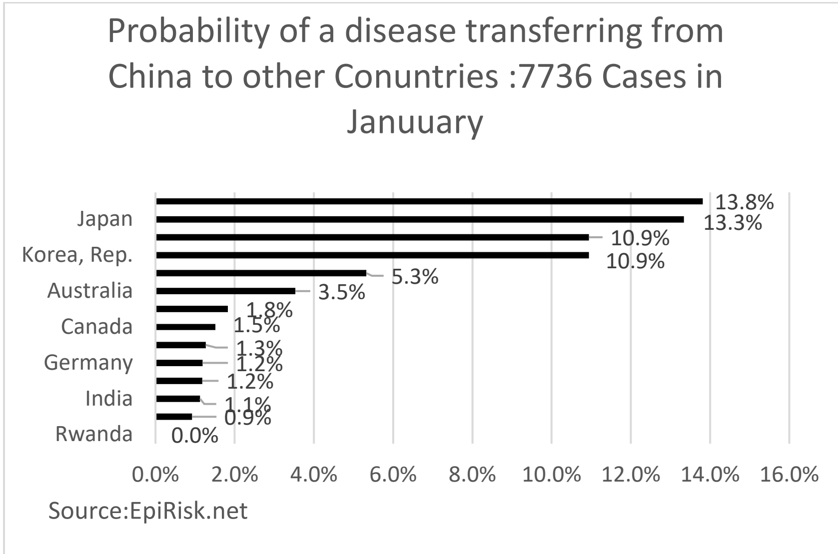


Figure 1. Probability of Disease Transfer

The graph above and the simple classical probability illustrates close geographical and proximity, and population density can increase the transmission risk. In this situation, it can be seen that the growth rate of the number of cases increases across the time series. Therefore, this provides indication that a logarithmic function could be useful for predicting the short term increase in cases over a certain period of time. During the early onset of an outbreak in a region, scientists in close contact (geographical or human based) countries can utilize these statistical tools to gather inferential observations and further communicate their finding to local health department officials so that government and private officials have the opportunity to assess the impact and take proactive and effective preparedness measures.

Predictive and Correlative Analysis for Effective Communication

The next phase after observing the probability of an outbreak coming from one region to the next and establishing that there is a very good chance that an outbreak can occur, understanding the severity of impact that the outbreak can have is crucial. In the case of local health departments in the United states, conducting comprehensive impact analysis is especially crucial for understanding how any centralized health system should optimize the resources they have and leverage the possible networks they operate to obtain future demands for supplies and labor that will aid in the monitoring, testing, and treatment phases of the outbreak. One of the first modes of analysis is understanding how great of an impact the outbreak can have on a region. One way of doing this is to utilize Least Squares regression analysis. The cross-sectional aspect of regression analysis can display factors that can be significantly correlated with the number of cases in a region. The time series aspect of regression analysis can show the effect of an outbreak overtime. From a predictive standpoint, data analysts in the potential outbreak region can run various regressions for areas that have similar institutional health and demographic structures to see how the impact of the outbreak can occur before it arrives in the area. For example, we conducted a series of cross- sectional regression analysis to see the possible significant correlation that a variety of variables have on the case rate (case/population) in America. The regression analysis followed the Ordinary Least Squares regression model structure illustrated in Equation 1

$Y = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n + \varepsilon$ Equation 1

with normally distributed error terms of $N \sim (0,1)$ where the expected value of the error terms is 0 and the variance of the error terms is 1, and a 95% confident interval. The first regression took a sample of 13 states in the US and observed the correlation between state health department response times to the health warnings from the Center for Disease Control through early COVID-19 testing (the amount of hours from the first time that the CDC raised awareness of the potential dangers of the novel coronavirus- labeled CDC(hrs)*) and the Number of cases in the states(labeled Cases).

Table 2 .1 Case Rate Modelling based on State Department Response Times

Modelling Cases by OLS-CS					
Variable	Coefficient	Std.Error	t-value	t-prob	.R^2
CDC(hrs)*	27.6167	9.173	3.01	0.0109	0.4303

Table 2.2 Model Characteristics

Model Characteristics	
sigma	33085.4
RSS	1.31E+10
log-likelihood	-153.215
DW	1.56
mean(Cases)	25119.5
var(Cases)	1.14E+09

Table 2.1 and 2.2 illustrate the correlation between the CDC response time and the number of cases in the 13-state sample size. The results indicate that an increase in response time of 27 hours can be significantly correlated with one new case in a state and that the response time explains 43% of the variation in cases around the mean, which may not be a large percentage, but it is a good start of an indicator that displays the importance of taking a proactive approach to responding to health agency warnings by early detection methods of COVID-19 testing. This is a useful communication tool because it first illustrates the transmission risk for the virus if quick response measures are not taken, and then it illustrates that, while early detection methods may not guarantee less outbreak cases, they can allow health department authorities to make more informed and thus effective response decisions surrounding the outbreak in the region at an earlier time, thus possibly leading to more recovery cases.

The second cross sectional regression model takes a sample of 50 US states and observes a possible impact that a COVID-19 outbreak could have on a state with proportionately large numbers of health and population vulnerabilities such as high population density, which could increase the risk of transmission, and a state that has had a larger population of deaths related to respiratory illnesses. We ran a regression that observed the correlation between these two variables and the cases rate (case in terms of population). The results can be found in Table 3.1 and 3.2

Table 3.1 COVID Case Rate Modeling Based on Health Vulnerabilities

Modelling Total Cases In proportion to the population by OLS-CS					
Variable Name	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Population Density (population per sq mile)	6.5559E-07	2.393E-07	2.74	0.0086	0.1328
Chronic Lower Respiratory Disease Death rate	4.0878E-05	0.000009072	4.51	0.00	0.293

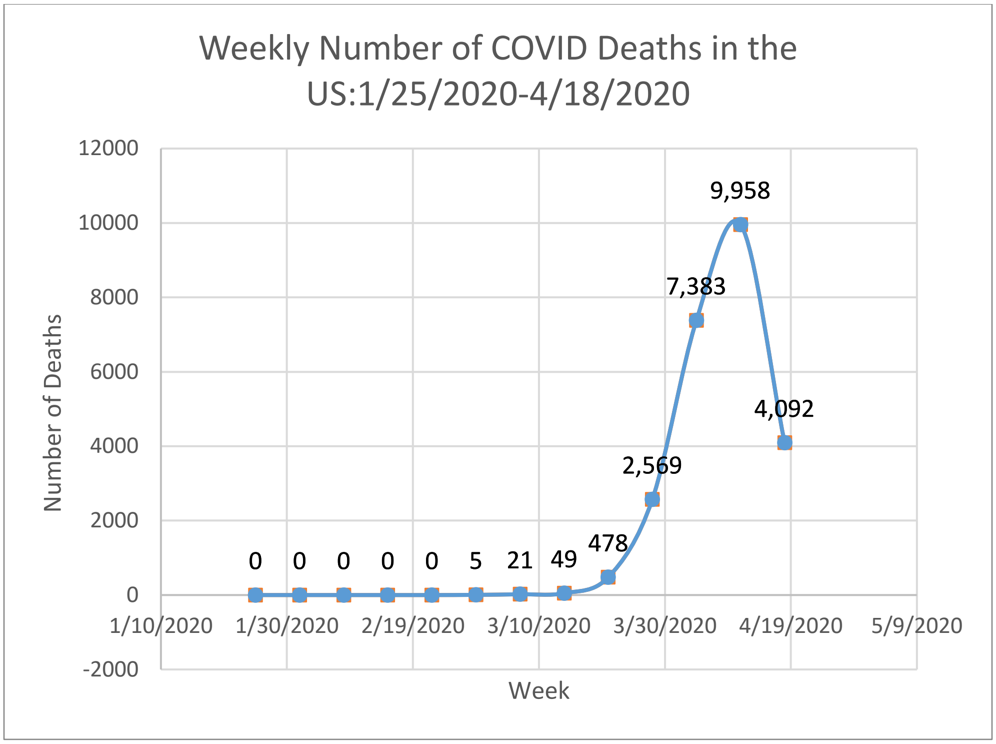
Table 3.2 Model Characteristics

Model Regression Characteristics	
sigma	0.00281092
RSS	0.00038716
log-likelihood	228.241
DW	2.02
no. of observations	51
no. of parameters	2
mean(Y)	0.00228601
var(Y)	7.10E-06
R^2	0.4258

As can be seen in the top two tables, population density and chronic respiratory disease rate have small, but significantly positive correlation coefficients to case rate increases within the states. Furthermore, the model explains close to 43% of the variation in case rates. This type of information is useful because it shows the effect that COVID-19 transmission can have on states that have history with larger populations of pre-existing illnesses that may be exacerbated by a virus such as COVID-19 that is known to have a significantly negative impact on an infected person's respiratory system. It then further reinforces the point that states with high population densities are at higher risks of transmission.

Case Growth Over Time to Aid in Future Supply Chain Management Demands

Statistical techniques that can estimate the growth rate of cases in an infected region over time is critical because, it provides insight on how a health department should gauge the supply chain and medical resource needs of a region. If we recall the simple probability example in Table 1, the growth rate of the known cases followed an increasing trend as the time progressed. In the short term, this is a good indication of the growth trend of cases, thus allowing health department officials to predict the increase in cases over a span of time. If we look at the graph below that illustrates the amount of deaths from COVID-19 in America from January 25, 2020 to April 18, 2020, we can see that the shape of the curve before April 18 closely resembles that of a logarithmic trend.



(Source : CDC, 2020)

Graph 1. Weekly Number of COVID Deaths

Thus, from growth patterns like this and growth patterns of living cases, a log time series regression analysis can be useful in estimating the case growth rate, future needs for medical supplies, the estimated growth rate, and the overall cost to the health industry. We conducted a log-log regression analysis that shows the possible cost burden in hospital expenditures that the COVID-19 virus can have on the American public, as well as the costs that can be associated with late health department emergency responses and number of deaths from the virus. We used an estimated per-person inpatient cost that COVID-19 can have on a person and the number of deaths in the US by week.(Cohen et.al, 2020)   The model uses the structure below in Equation 2

$$log Total\ Cost\ Based\ on\ Estimated\ ICU(inpatient)_t = log Number of Deaths x_t + \varepsilon_t$$

Where the equation was ran under Ordinary Lease Squares with a normal distribution of $N\sim(0,1)$ with mean 0 and a variance of 1. The results are displayed in Table 4.1. and 4.2.

Table 4.1 Cost Based Modeling

Modelling LTotal Cost based on Estimate: ICU (Inpaitent) by OLS					
	Coefficient	Std.Error	t-value	t-prob	Part.R^2
LNumber of Deaths	2.37107	0.1890	12.5	0.0000	0.9633

Table 4.2 Model Characteristics

Regression Model Characteristics			
sigma 3.57352	RSS 76.6202991	mean(Y) 17.1097	var(Y) 5.22664
log-likelihood -18.3079	DW 0.263: Evidence of Positive Autocorrelation	no. of parameters 1	no. of parameters 1

These results indicate that there is a significantly positive correlation between the number of COVID-19 related deaths and COVID-19 related hospital costs. This model can be used to analyze situations with similar growth patterns such as cost of medical supplies and personal professional equipment. Very often the trends of an outbreak follow a function that has peaks during certain time periods and valleys during others, thus displaying a trigonometric function trend (Rigdon and Figder, 2019). Epidemiologists can utilize models such as the Serfling(1963) model trigonometric function that calculates the expected value of mortality rates from influenza cases using weekly data

$$E(yt) = \mu + \alpha t + Xr\ i=1\ \{\beta i \sin(\omega it) + \gamma i \cos(\omega it)\} \qquad \text{Equation 3}$$

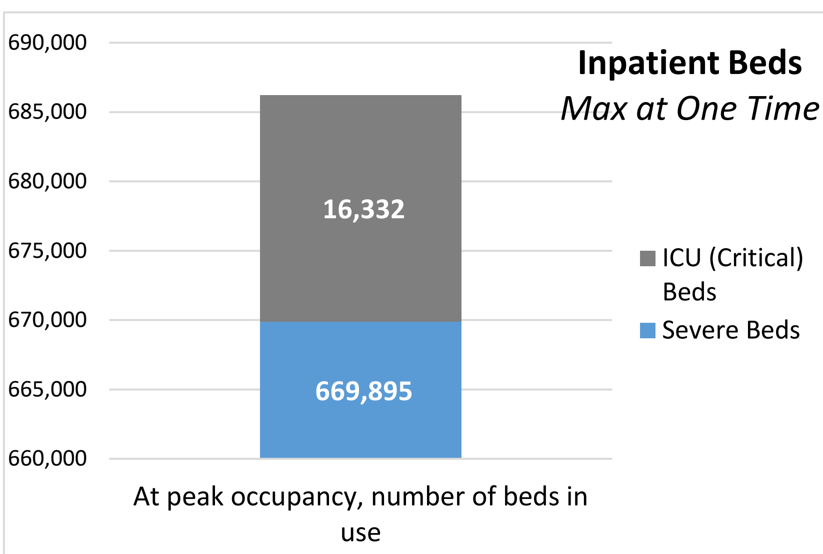
Models such as these display the possible phases of the transmission process during an outbreak (Unkel, et al, 2010).

Health Department Analysis and Supply Chain Coordination

One of the last phases in the communication process for emergency preparedness is analyzing the future medical supply needs of a state during a pandemic. Through combining different statistical and supply chain optimization models, health departments can gain quick and precise insight on their future medical supply needs. On a global scale, one useful supply chain estimation tool is the World Health Organization Materials Forecasting tool that provides a user friendly method of estimating how many medical materials a department or organization might need when going into an infected area. The tool collects user inputs surrounding the country name, number of cases in the country, the estimated growth trend, hospital bed usage in the region, delivery time, and medical resource usage. Then, it predicts the supplies needed for the estimated cases that might occur in the target region. Germany and Rwanda's example are below:

Germany

Germany - High-Level COVID-19 Needs Outputs



Setting	Number of Staff Required Each Week	First week of forecast	Week 2 of forecast	Week 3 of forecast	Week 4 of forecast
Inpatient	Total number of medical practitioner	150619.8154	506622.6512	661160.4211	661160.4211
	Total number of Cleaners and Helper	75309.90768	253311.3256	548981.6	548981.6
	Total number of caretakers required	94137.3846	316639.157	1065042.928	2144169.841
	Total number of ambulance personne	1882.747692	6332.78314	21300.85856	42883.39681
Outpatient screening	Total number of medical practitioner	47568	159998	516531.5789	516531.5789
Laboratories	Total number of lab staff required	2066	6948	15054.4	15054.4
	Total number of Cleaners and Helper	689	2316	7790	14900

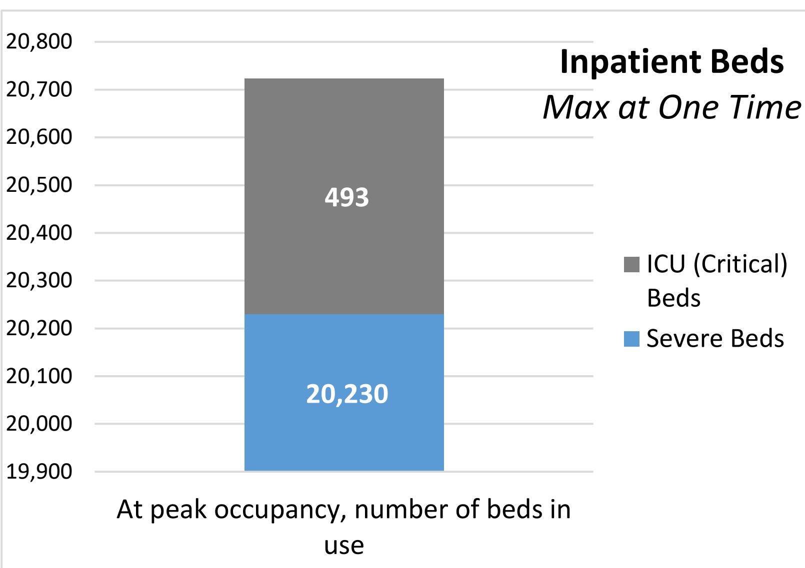
Detailed Equipment Quantification

These prices are estimates only. Prices are rapidly evolving based on market fluctu

Category	Grouping	Item	Total quantity	Estimated price/unit	Estimated total price
IPC	Hygiene	Chlorine, HTH 70%	248,264	$ 4	$ 868,924
IPC	Hygiene	Alcohol-based hand rub	6,880,092	$ 8	$ 57,104,764
IPC	Hygiene	Liquid soap	419,996	$ 1	$ 377,996
IPC	PPE	Gown, protective	30,680,732	$ 1	$ 24,544,586
IPC	PPE	Scrubs, tops	863,337	$ 3	$ 2,244,676
IPC	PPE	Scrubs, pants	863,337	$ 3	$ 2,244,676
IPC	PPE	Apron, disposable	10,621,815	$ 0	$ 2,124,363
IPC	PPE	Apron, heavy duty, reusable	274,491	$ 4	$ 1,097,964
IPC	PPE	Gum boots	274,491	$ 5	$ 1,262,659
IPC	Diagnostics	Triple packaging boxes	68,624	$ 30	$ 2,058,720

Source: World Health Organization

Rwanda - High-Level COVID-19 Needs Outputs



Setting	Number of Staff Required Each Week	First week of forecast	Week 2 of forecast	Week 3 of forecast	Week 4 of forecast
Inpatient	Total number of medical practitioner	13520.39298	13520.39298		
	Total number of Cleaners and Helper	16578.4	16578.4	16578.4	16578.4
	Total number of caretakers required	27987.21189	94137.3846	316639.157	172332.849
	Total number of ambulance personne	559.7442378	1882.747692	**6332.78314**	3446.65698
Outpatient screening	Total number of medical practitioner	10562.80702	10562.80702	10562.80702	10562.80702

Source: WHO

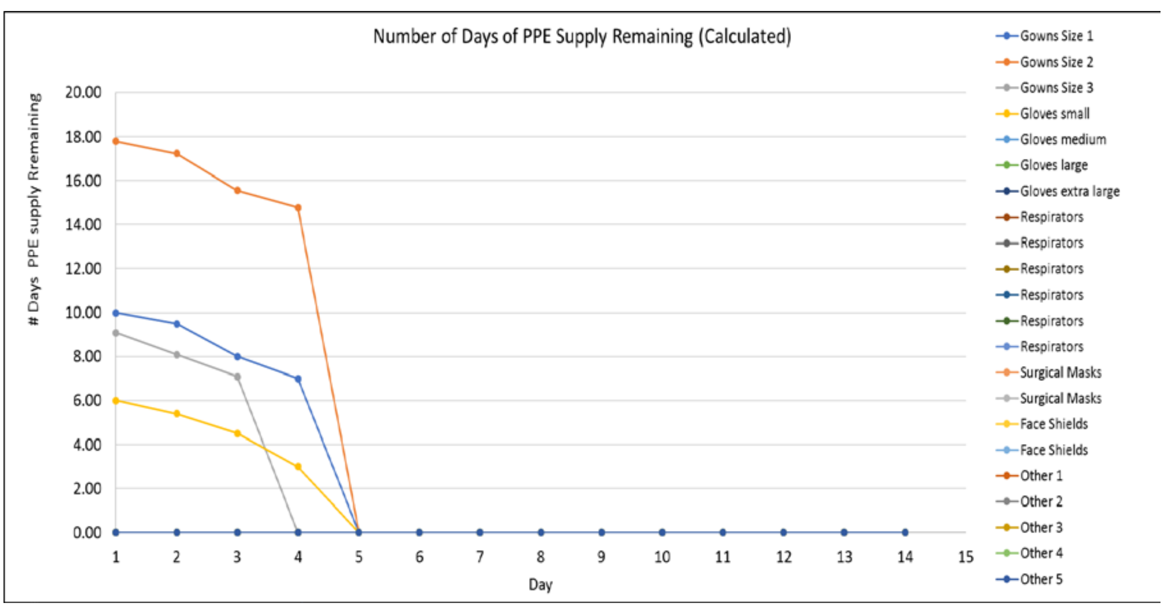
Detailed Equipment Quantification

These prices are estimates only. Prices are rapidly evolving based on market fluctu

Category	Grouping	Item	Total quantity	Estimated price/unit	Estimated total price
IPC	Hygiene	Chlorine, HTH 70%	14,639	$ 4	$ 51,237
IPC	Hygiene	Alcohol-based hand rub	976,292	$ 8	$ 8,103,224
IPC	Hygiene	Liquid soap	16,061	$ 1	$ 14,455
IPC	PPE	Gown, protective	1,211,836	$ 1	$ 969,469
IPC	PPE	Scrubs, tops	20,331	$ 3	$ 52,861
IPC	PPE	Scrubs, pants	20,331	$ 3	$ 52,861
IPC	PPE	Apron, disposable	392,628	$ 0	$ 78,526

Source: WHO

The Burn Rate calculator allows health department analysts and officials to enter case scenarios that illustrate the amount of protective equipment that can be used over a certain period of time. This, in turn ,allows supply chain personnel to see when the depletion times.. See Graph 3 below:



Source: CDC

Graph 3. Number of Days of PPE Supply Remaining

Pulling Things Together

The preparation for emergency response is a crucial and very time sensitive role during the process of predicting a major outbreak. This time period needs to involve effective communication between all relevant health department officials. In the warning stages of outbreaks, epidemiologists can utilize predictive measures to estimate the probability that a transmittable disease will spread from one region to another, and spread rate. Further, epidemiologists and health department analysts should be in close communication when observing the various areas that can be especially vulnerable to the virus in question so that they can get a proper gauge on the capacity of preparation that needs to be done for effective response of the outbreak. Regression models and probability statistics that include vital indicators of health and population vulnerability of various regions can be extremely helpful in making adequate predictions and understanding strong correlation relation. After reliable risk and vulnerability assessments, communication and coordination with supply chain teams is to understand the costs and the quantity of medical supplies

Supply Chain and Logistics Challenges for Humanitarian Missions

There are many challenges involved with delivering goods to a country after a natural disaster.
Most of the challenges stem from human and government interactions, political interests, poor infrastructure and more as listed below. [3]

- International humanitarian organizations have responsibilities to three groups who provide funds
- Lack of funding is aimed at management
- Establishing a flow of donations from different sources such as national and international
- Involves nonvalue added activities, increased cycle time, and waste of resources; disposing poor quality and overwhelming quantity of information is needed to make frequent decisions
- Administration and logistical bottlenecks due to poor infrastructure receiving the goods and multiplicity of agencies and governments
- Coordinating difficulties due to political interests
- Civil unrest in recipient
- The requirements of industries of donors and lack of unrest in recipient
- The requirement of industries of donors and lack of coordinated plans
- Insufficient communications between field and the bases of the humanitarian government

Mitigating Circumstances that Prevent Aid to Recipient Countries

- Remote locations
- International humanitarian and stakeholder causes complexity
- Governments
- Nongovernmental organizations
- United Nations
- Military and private section organizations
- Individuals in the humanitarian operations with different management styles and admin structures
- Complex relationship between organizations

Simple Supply Chain Process Map for Humanitarian Aid

This model is used for many humanitarian missions and scenarios. It allows a single flow of goods and equipment to affected areas where needs are great. [4]

[3] Da Costa, S., Gouvea Campos, V., De Mello Bandeira, A. Supply Chains in Humanitarian Operations: Cases and Analysis, Available: https: pdf. Sciencedirectassets.com/277811/1-s2-S187704812X00259/
[4] Oloruntoba, R. Gray, R. Humanitarian aid: an agile supply chain?, Supply Chain Management, Vol. 11 No. 2, pp115-20

The success of the missions are due to data gathering and planning of general information which is: needs assessment, size of the affected populations, adversity vulnerability, damage levels, and preexisting poverty. Also, the logistical information and plans are equally crucial to the success of the mission. Logistic information studied are: distance from the hub, transportation capacity, day access roads open, and existing cargo handling orders.

Six Sigma Tools for Analyze

According to the ISO 9001:2015 "Risk and Opportunities now need to be considered for all aspects of the Quality Management System (QMS).[5]" SF Consultant Team completed a Failure Mode and Effects Analysis (FMEA) to illustrate risk management plans for the solutions. The purpose is to analyze how failure modes affect the system and to minimize failure effects upon the system.[6]

WHY: Potential Cause(s) of Failure	Occur	Current / Future Controls	Detect	RPN	Recommended Actions (Response Plans: SOP's, Containment, Control Plans)	Responsibility and Target Date Completion	Action Taken	Severe	Occur	Detect	RPN
Healthcare works are exposed and at risk of contagon even death.	9	National stockpile and 5 major preferred vendors for emergency medical supplies	1	81	Develop a rodeo fair for healthcare to start connections, communications, and networks - target 5 health departments and 4 hospitals	11/2/20					0
Patients and healthcare workers will be at risk of a pandemic	9	National stockpile and 5 major preferred vendors for emergency medical supplies	1	90	Locate other manufacturers that are capable of emergency medical supply production	11/3/20					0
Patients and healthcare workers will be at risk of a pandemic	10	None	1	100	Gather a coilition and plan strategy for meeting. Meet with leadership to devleop the process.	12/12/20					0
				0							0
				0							0
				0							0
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				0							0

Improve

The "Improve," phase enables us to find the improvements that will fix the root cause of the problem. The "5 Whys," is an excellent tool to identify root causes. Pilots are geared to test the solution and verify the desired performance goal. Improvement plans are used for Six Sigma projects.

Six Sigma Tool for Improve

The process for building a pilot is similar to developing an improvement plan. [7]The process is:

1. Identify all improvements
2. Prioritize all improvements
3. Break down improvements into actions
4. Identify pre-requisite or sub-actions
5. Assign action owners and due dates

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[5] ISO Update, Available: http://isoupdate.com/resources/risk-management-in-iso-90012015/ , 2018

[6] Wortman, W., Richardson, W., Gee, G., Williams, M. Pearson, T., Bensley, F., Patel, J., DeSimone, J., Carlson, D. , ASQ, CSSBB Primer, 2nd Edition, Quality Council of Indiana, 2007

[7] Hansen, M. Lean Six Sigma The StatStuff Way, 1st Edition, Essential, 2013

COVID-19 Improvement Plan for Health Department

Item #	Action	Improvement Action	Prereq	Priority	Owner	Due
1	1	Identify hospitals in close proximity		M	Angelice	6/20/20
1	2	Identify health departments in close proximity		M	Angelice	6/21/20
1	3	Contact and develop healthcare networks to engage in negotiation partnership for emergency supplies and equipment .	1.1, 1.2	H	Angelice	6/22/20
2	4	Meet with leadership to identify team members		H	Angelice	7/15/20
2	5	Met with team to develop a strategy for HUBs and local delivery options		H	Angelice	7/20/20
2	6	Establish HUBs and local delivery options for materials and supplies	2.4, 2.5	H	Angelice	7/30/20
3	7	Identify alternatives resources for manufacturing medical supplies		M	Christina	5/15/20
3	8	Research and verify vendor performance		H	Christina	6/2/20
3	9	Contract for emergency equipment and supply	3.7,3.8	H	Christina	6/29/30
4	10	Meet with several health departments to gain support to petition CDC for realtime pandemic/emergency information without political intervention.		H	Christina	8/1/20
5	12	Meet with Sponsor, Sr. Management to discuss the need for a transportation, communication and technology infrastructure improvement		H	Christina	8/25/20
5	13	Meet with sponsor to identify team members		H	Christina	
5	14	Develop a plan for transpotation, communication and technology infrastructure improvements	5.12, 5.13	H	Christina	3/30/20
IMPROVE		**SF Consultant Team: S. Floyd, C. Floyd, A. Floyd**				

Control
Our goal in the "Control," phase is to sustain the improvements that fixed the root cause of the problems. Therefore, we must implement statistical process controls (SPC). SPC is a technique for applying statistical analysis to measure, monitor, and control processes. [8] Since all processes are subject to variation, we apply SPC to sustain desired performance. When special cause variations occur, these controls make it easily identifiable to investigate and resolve problem to meet department goals. Benefits of control charts are to track performance, predict performance, and monitor continuous improvement. Training employees the new process, writing standard work instructions, and sharing lessons learned are necessary to sustain improved performance.

Six Sigma Tool for Control
Since, measuring and monitoring is crucial, we decided to build a dashboard for Sr. Management and Managers. It's a snapshot report of multiple metrics at the higher level of business. Additionally, we designed a scorecard which monitors key metrics for day-to-day operations. The scorecard is useful to all leaders and workers.

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Appendix A

SUSTAIN		
Characteristic	Dashboard	Scorecard
# of Metrics Required	4 or more	6
Method to Display Metric	Snapshop	Trending
Organization Level	High (executive level)	Mid Level Mgrs to process level
Characteristic		**Scorecard**
Process Metric		# of Accurate Triage Reporting
		# of Accurate COVID-19 Test Results
	Item/Action	
Improvement Metric	1.3	# of established healthcare negotiation partners
	2.6	# of established Hubs and delivery options
	3.7	increase alternative resources for manufacturing medical supplies by 5%
	5.15	# of stakeholders approving the first draft of the plan
	3.9	Establish three contracts for emergency equipment and supplies
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SF Consultant LLC
Project Charter

Team Members: Sharon Floyd, CSSBB, Christina Floyd, SME, Angelice Floyd, Data Analytic Statistician

Background Statement: (i.e. historical context for the business area)
The Novel Corona Virus Pandemic began during the last quarter of 2019 in Asia and foreign countries. It is a new virus and has no solid case definition. There is no vaccine available. Social distancing and corantine are used to combat the disease and initially seems to flatten the number of cases. It's rapid spread has claimed almost many lives worldwide. Symptoms are shortness of breath, trouble breathing, and dry cough. Medical supplies have not been readily available to Health Care Workers.

Problem Statement: (i.e. symptoms, pain felt by the organization)
Communication issues resulted in a lag for the response time for many Health Departents. Delays with test caused community wide-spread infections, 895,766 confirmed cases and total deaths 50,439. Supplies and Professional Protective Equipment (PPE) were delayed for front-line health care providers and responders. Heath Care Workers were exposed and infected and some have lost their lives. Originally, COVID was not added to the Surveillance System, therefore states could not account for confirmed cases. Identifying clusters to stop the spread of infection was a challenge.

Project Scope (i.e. included and excluded)
Emergency Response Readiness for Covid19 for Health Departments and Globally Health Authorities.

Current Situation (i.e. how it works today, agencies or people involved)
World Health Organization provides information to the Center of Desease Control-US and Health Authorities globally. CDC disemminates information to the Health Department. Health Departments provide guidance and customer services to the communities.

Goal Statement: (i.e. objective of the science fair)
The goal is to develop statistical analysis of conditions globally and determine if difference exists between countries, additionally the model curve and determine time frame to "Flatten Curve" for particular country or region. The case study will allow the participants to gain awareness, knowledge and critically demonstrate the application of DMAIC strategy to resolve complex processes.

Benefits (i.e. desired achievement, benefits to department, state, nation etc...)
The findings will be published for future references.

Business Case/Financial Impact
States that thrive on tourism have been severly impacted due to the shutdown. There are substantial loses of job in the Health Care and other industries. 22 Million people have filed for unemployment thus far. Financial Impact will be displayed in the Analysis.

The lack of communication and supply chain coordination within State Departments that lead to inadequate emergency preparedness resulted in significant individual medical and hopsptial cost and aggregate State expenditure costs

Project Strategy/Solution Process (i.e. science requirements, gate requirements, components of solution strategy, challenges of problem solving, leader from the organization, what role will I play, role of team members, concerns with my ability to meet this role etc..)
SF Consultant team is requested to focus on a specific country or region of our choice that has been significantly impacted by the Covid-19 pandemic. Six Sigma encompasses tools to make statistical comparison between population samples. It contains has methodology to perform predictive analysis.

SF Consultant has been tasked to resolve a complex global concern. Applying the DAMIC process teams must provide statistical analysis of Covid-19 pandemic. Depending on the selected approach to address the concern different tools will be employed throughout DMAIC process to narrow Key Process Input Variables (KPIVs) that are driving unacceptable output(s). The report must also incorporate the following minimum requirements:

Milestone/Deliverables (i.e. end products of the project etc...)
Country Analysis to determine statistical difference, Prediction to flatten curve under different scenrios, Supply Chain requirement, Region or Country heavily impacted and apply statistical analysis on the pandemic us DMIAC, Identify using tools KPIV driving unacceptable performance or KPOV,

Decision Process (i.e. winner criteria/score, decision steps, who is involved, time frame etc...)
Clearly and effectively structured and communicated report
Demonstration of a clear understanding of supply chain and logistics challenges within the context of humanitarian missions
Clear demonstration of the application of supply chain and logistics theory, concepts, methods and/or tools to solve complex supply chain and logistics
Clear demonstration of the use of effective analytical and technical skills to solve supply chain and logistics challenges
Clear demonstration of knowledge and skills to formulate and develop an implementation plan for a supply chain and logistics strategy
Good and effective report's presentation

Resources Required
Data and analytical tools