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COVID 19: Situation, Action, and Tracking of PPE Demand in the U.S.

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ABSTRACT

During the COVID-19 Pandemic, healthcare systems across the United States have experienced severe shortages of Personal Protective Equipment (PPE). This equipment is critical for the proper protection of healthcare workers while they perform patient care for COVID-19 patients. Identifying the need for PPE for doctors, nurses and other healthcare workers was a major challenge in the United States. The aim of this research is to understand how the need for PPE was tracked in the US and comparing these methods with approaches in other countries with far better outcomes.

This paper is intended to provide an in-depth understanding of how in the absence of leadership from the Federal Government, non-profit organizations, universities, and others created working systems for tracking COVID-19 patients and estimating PPE needs. The first and most critical needs for PPE were for doctors, nurses and other healthcare professionals in hospitals and other healthcare organizations such as extended-care facilities caring for infected patients. Immediately it became clear that PPE shortages for first responders, other essential workers, and members of the public were also hampering the control of the virus.

The main contribution of this paper is a recommendation for the US that includes PPE prediction models to have a better understanding of PPE needs and requirements.

Keywords: Covid-19

1. Introduction

Late 2019 and throughout 2020 will be long remembered for witnessing one of the most devastating viruses, the novel coronavirus (COVID-19), in the history of mankind. Since its first appearance in November 2019 in China, the virus has spread worldwide quickly(Scher, 2020). The situation became so bad that it was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (Ducharme, 2020). Among all the countries, the USA has been the prime victim with the highest number of COVID-19 cases and deaths (Linnane, 2021). The situation could have been worse. The US government has implemented many policies

like screening at the port of entry, travel restrictions, travel bans, stay-at-home lockdowns to fight COVID-19 (CDC, 2020g; Mervosh et al., 2020; The White House Proclamation, 2020a). The US healthcare professionals have been heroic with their restless duties under highly vulnerable condition during this time (Parins, 2020). However, the US government has failed to ensure needed Personal Protective Equipment (PPE) for them (Jacobs, 2020). Eventually, many healthcare professionals became infected and lost their lives due to COVID-19 (Stone & Feibel, 2020). This paper is investigates the COVID-19 and PPE situation in the USA. Based on existing research papers, peer-reviewed journal articles, newspaper articles, presentations, blogs and other information media, in this paper we explore how the US has performed so far in this global pandemic. Moreover, the tracking and distribution of PPE is investigated in light of international examples to assist in future decision making in case such a crisis occurs in the future.

2. The Scenario of COVID-19 in the USA

COVID-19 has struck the US more seriously than any country in the world (WorldOMeter, n.d.-a). In January 20, 2020, the first COVID-19 case was detected in the US (Holshue et al., 2020). Since then, this virus has become increasingly worse for citizens, healthcare professionals and the government itself. In this section, the scenario of COVID-19 in the US is been explored in-depth.

2.1 Timeline of cases

In mid-January 2020, COVID-19 started spreading outside China. Thailand and Japan were the first and second countries outside China that confirmed a COVID-19 case (Joseph, 2020; Schnirring, 2020). Consequently, the Centers for Disease Control and Prevention (CDC) started to screen travelers at three US international airports, namely Los Angeles (LAX), San Francisco (SFO), and New York (JFK) on January 17, 2020 (CDC, 2020g). Despite the precautions, the virus first appeared in the US through a 35 years old male in Washington (Holshue et al., 2020). From then, the virus began infecting people of all ages across the country. The death numbers also kept rising rapidly. In just four months, in late-May, 2020 the number of deaths reached 100,000 (Winsor et al., 2020). At the end of the year 2020, the total number of cases globally was approximately 100 million and the United States accounted for 25% (25.4 million) of the total global number. The total number of deaths globally had reached 2.16 million, with 25% (0.425 million) from the United States (Johns Hopkins University & Medicine, n.d.). A look back at how the pandemic progressed in the 12 months of 2020 is shown in Table 1.

Table 1. The United States COVID-19 Timeline (AJMC Staff, 2021; Guarino et al., 2020)

January	January 9, 2020	A Mysterious Coronavirus-Related Pneumonia found in Wuhan, China - WHO announces
	January 20, 2020	3 US Airports Will start Screening for Coronavirus
	January 20, 2020	First Coronavirus Case in the US
	January 31, 2020	WHO declares Global Health Emergency
February	February 2, 2020	US restricts global air travel
	February 3, 2020	US issues Public Health Emergency

	February 25, 2020	CDC declares that the virus is moving towards pandemic status
March	March 6, 2020	21 Passengers on Carnival Corp Cruise Ship are infected
	March 11, 2020	WHO declares COVID-19 is a Pandemic -
	March 13, 2020	President of the US declares COVID-19 is a National Emergency
	March 13, 2020	US puts travel ban on Non-US Citizens coming from Europe
	March 17, 2020	University of Minnesota starts Testing Hydroxychloroquine
	March 17, 2020	US President asks government to send financial relief to Americans
	March 19, 2020	California Issues Stay-at-Home Order
	March 26, 2020	The United States Senate Passes CARES Act
	March 30, 2020	FDA issues authorization for Hydroxychloroquine
April	April 28, 2020	Reports suggests young, poor avoid care for COVID-19 Symptoms
	April 29, 2020	NIH Trial Shows Early Promise for Remdesivir
May	May 1, 2020	An EUA was granted by FDA to Remdesivir
	May 9, 2020	FDA authorizes Saliva-Based Diagnostic Test
	May 12, 2020	Dr. Fauci Testifies that the death toll likely underestimated
	May 28, 2020	US death toll passes the 100,000 mark
June	June 4, 2020	Studies on Hydroxychloroquine for COVID-19 were retracted by both *Lancet* and *NEJM*
	June 10, 2020	US passes 2 Million COVID-19 cases
	June 16, 2020	DHHS declares that COVID-19 Vaccines will be free for old and poor
	June 26, 2020	White House Coronavirus Task Force discusses rising number of cases in the southern states
	June 29, 2020	Gilead Sciences announces price for Remdesivir as $3120
	June 30, 2020	Dr. Fauci states new COVID-19 cases could reach 100,000 a Day

July	July 2, 2020	Multiple states postpone or reverse their plans to reopen businesses
	July 7, 2020	US surpasses 3 million COVID-19 cases
	July 16, 2020	US reports a record new 75,600 cases per day
	July 21, 2020	Experimental vaccines show promising results
	July 27, 2020	Moderna announces phase 3 trials for its vaccine
August	August 3,2 020	WHO publishes COVID-19 Preparedness and Response Progress Report
	August 4, 2020	Rural communities lack ICU beds
	August 12, 2020	COVID-19 mortality risk increases for obese population
	August 13, 2020	Former VP Joe Biden requests governors to implement mask mandate
	August 15, 2020	FDA provides authorization for saliva tests
	August 17, 2020	Covid-19 ranks 3 in the cause of deaths in the US
	August 25, 2020	CDC revises Testing Guidance
	August 28, 2020	COVID-19 reinfection found in the US
September	September 1, 2020	US rejects distribution of COVID-19 vaccine COVAX
	September 3, 2020	GSK starts human vaccine trials
	September 8, 2020	AstraZeneca stalls phase 3 vaccine trials
	September 14, 2020	US stops screenings at airports
	September 15, 2020	CDC announces the spread of infection at restaurants
	September 16, 2020	The US government releases distribution plan for the vaccine
	September 17, 2020	Sharp increase of COVID-19 cases reported in Europe
	September 21, 2020	CDC reverses statement that COVID-19 may spread via airborne transmission
	September 28, 2020	COVID-19 deaths surpass 1 million globally

October	October 2, 2020	President Trump and Melania Trump tested positive for COVID-19
	October 12, 2020	Johnson & Johnson stalls vaccine trials
	October 15, 2020	COVID-19 cases in the US spike again
	October 19, 2020	COVID-19 cases surpass 40 million globally
	October 22, 2020	Remdesivir becomes the first approved drug for COVID-19
	Oct 30, 2020	US passes 9 million COVID-19 cases
November	November 4, 2020	More than 100,00 new cases have been reported in the US for the first time
	November 9, 2020	President-Elect Joe Biden announces transition team for COVID-19
	November 9, 2020	US passeds10 million COVID-19 cases
	November 18, 2020	Vaccines from Pfizer and BioNTech are estimated 95% effective
	November 23, 2020	Vaccine from AstraZeneca is estimated 90% effective
	November 27, 2020	US passes 13 million COVID-19 cases
December	December 2, 2020	US passes 14 million COVID-19 cases
	December 14, 2020	US starts first vaccinations
	Dec 24, 2020	CDC announces testing requirements for travel from UK
	Dec 31, 2020	US vaccinates 2.8 million people by end of 2020

2.2 Current Situation

Almost a year has passed, but the situation remains quite serious. December 2020 started with 165,200 daily cases and 1660 average daily deaths from COVID-19 (IHME, 2020). During the month of December, the US witnessed a rising rate of cases and death trolls (Dall, 2020). This month was identified as the deadliest month in the US with about twice as many deaths than in November 2020 (Maxouris, 2020). To fight the rapid rise of cases, the US planned to accelerate the vaccination process (Alonso-Zaldivar & Miller, 2021).

On January 27, 2021 the number of COVID-19 cases are estimated to be 100,652,861 with 25,540,461 in the US (Johns Hopkins University & Medicine, n.d.). The death count in the US has reached 427,513 which is the highest in the world (Johns Hopkins University & Medicine, n.d.). A live COVID-19 map maintained by the New York Times shows the patterns of COVID-19 cases and deaths in the US.

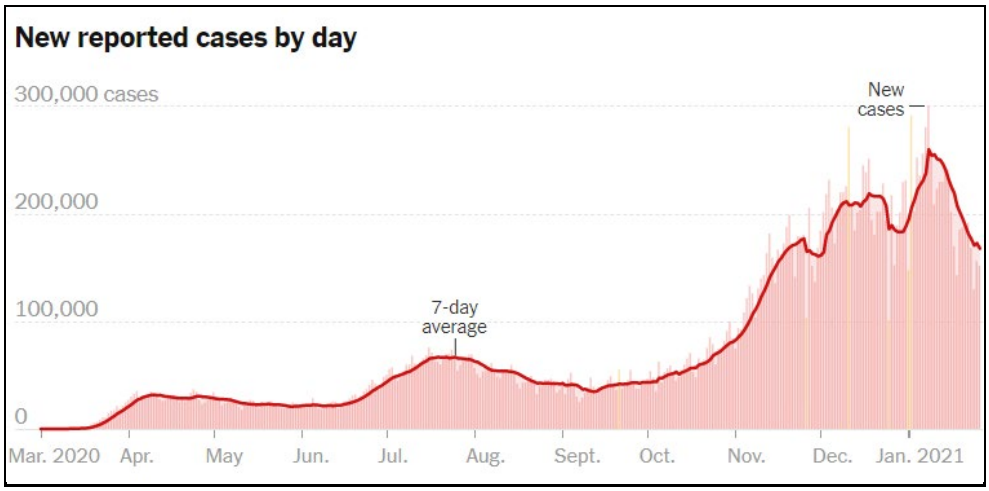

Figure 1. New reported cases by day in the US (The New York Times, 2020)

Figure 1 shows the seriousness of the situation is in the US over the past ten months. While December 2020 was perceived as the deadliest COVID-19 month (Dall, 2020), January 2021 is also daunting. Spikes are getting higher. The highest number of new cases was recorded on January 8, 2021. However, the decreasing trend in the last two weeks of January shows promise that the situation will be better in coming days.

The interactive map by The New York Times also contains graph for the number of daily deaths in the US illustrated as Figure 2.

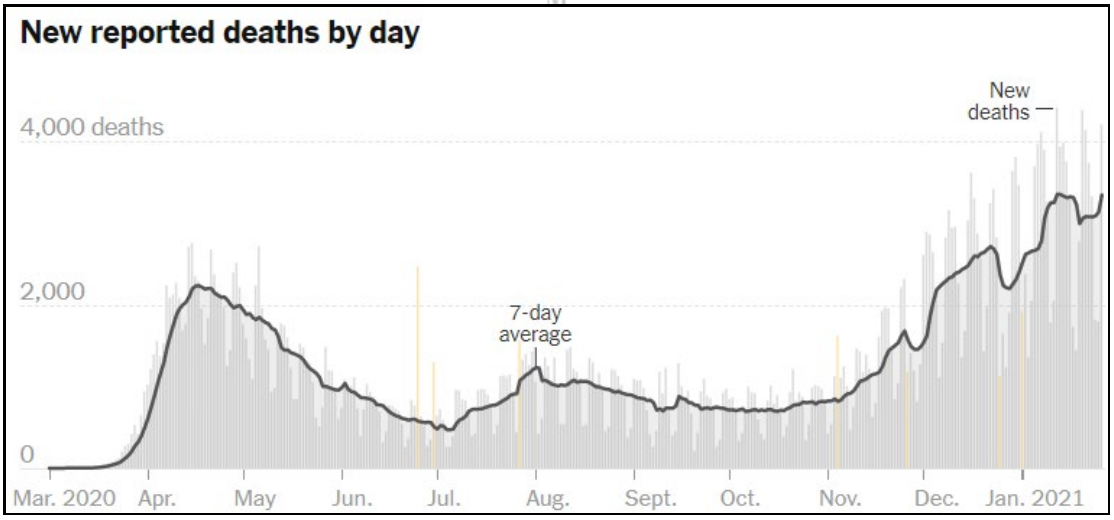

Figure 2. New reported deaths by day in the US (The New York Times, 2020)

Figure 2 summarizes how the nation's death count has changed over time. After April 2020, the situation improved with fewer deaths each day until some increases in August. The situation worsened from mid-November through the end of the year. The graph clearly shows the highest spikes in January 2021.

2.3 Personal Protective Equipment (PPE) shortage

Dr. Suzanne Schwartz, director of FDA's Office of Strategic Partnerships and

Technology Innovation at the Center for Devices and Radiological Health, defines Personal Protective Equipment (PPE) as "which when properly worn, helps protect the individual from different hazards such as physical, chemical, or biological ones. And by protecting from these hazards, that can then help prevent illness or injury" (FDA, 2020). When it comes to the COVID-19 healthcare situation, PPE consists of N-95 masks, surgical masks and surgical gowns or aprons, disposable gloves, eye goggles and face shields. As the coronavirus has been believed to spread via virus contaminated air or through contaminated surfaces, PPE is the boundary layer preventing the COVID-19 virus from entering bodies via nose, mouth , skin or eyes (CDC, n.d.). PPE is of utmost importance to the people who are being constantly exposed to this virus, especially healthcare workers, people in nursing homes and others in confined spaces.

From the beginning of COVID-19, the shortage of PPE in the US was visible (Cohen & Rodgers, 2020). In April, shortages of PPE for doctors and nurses were major news stories nightly on news broadcasts with pictures of doctors and nurses wearing trash bags as substitute gowns and homemade masks that offered little protection (Ankel, 2020; Parshley, 2020; Whitaker, 2020). It was terrifying to see healthcare professionals working under such vulnerability. The situation became worse instead getting better. A survey conducted by Society of Healthcare Epidemiology (SHEA) found respirator shortage in 40% healthcare facilities in July (Beusekom, 2020). At the end of August, 2020, statistics showed that more than 77% of healthcare facilities did not have one or more critical items of PPE in their stock (Get Us PPE, 2020). Improper maintenance of the Strategic National Stockpile (SNS) was held responsible by many for the crisis (Finkenstadt et al., 2020). Many others felt that lack of communication and supply chain disruption caused the huge crisis of PPE which put healthcare professionals under high risk (Raymond, 2020). Consequently, many healthcare professional lost their lives during this pandemic (Stone & Feibel, 2020). In addition to government initiatives and guidelines, some non-profit organizations, for example "Get Us PPE," came up to arrange emergency PPE (Baltimore, 2020; CDC, 2020d; Get Us PPE, n.d.). Despite all those efforts, US has failed to assure PPE even in early 2021 (Armour et al., 2020; Vaidya, 2021).

3. Government Response in the US

After the outbreak of COVID-19, the US government needed to come up with steps to ensure the safety of the citizens. However, no country had any clear idea of how to proceed to control this vicious virus. Person to person spread of the virus not only through air, cough, sneeze but also through contact surfaces as well as community transmission has imposed a major challenge to stop the spread of COVID-19 (CDC, 2020e; WebMD, n.d.). As a result, a proactive response was required. This section includes the actions taken by the US government in response to COVID-19 so far.

3.1 International travel Restrictions

Putting travel restrictions is one of the first things that the US government did as a response to COVID-19. It was mandatory to confirm that the virus was not carried from other countries through humans. So, the US Government started identifying vulnerable countries and placed travel bans from there for both immigrants and nonimmigrants. Entry from China, the originating country of COVID-19, was banned on January 31, 2021which was effective from February 2, 2020 (The White House Proclamation, 2020a). Iran was the second country to be banned, issued on February 29 with an effective date on March 2, 2020 (The White House Proclamation, 2020b). European Schengen area, UK, Ireland and Brazil were also included in that list in March 2020 (CDC, 2020f). Citizens living outside had been advised to return as soon as possible (M. Lee, 2020). Screening at the port of entry and mandatory home quarantine was assured for returning Americans (US Department of Homeland Security, 2020a). A 'no sail order'

was issued on March 14, 2020 so that COVID-19 does not spread through ships (CDC, 2020i). Avoidable travel had been urged to limit travel from the border countries Canada and Mexico (Anonymous, n.d.; US Department of Homeland Security, 2020b). It is worth mentioning that WHO was against the imposing of travel restrictions during COVID (World Health Organization, n.d.-b). The primary reasons behind that include difficulty in arranging emergency medical equipment, medical personnel traveling, return of crucial employees to the home country, and PPE supply chain crisis (Devi, 2020).

3.2 Intra and inter-states movement restrictions

The first case of COVID-19 was detected around mid-January 2020 in the US (Holshue et al., 2020). Beside ensuring that the virus does not enter into the country through someone, it was also essential to make sure that it does not spread from the affected ones. Moreover, many cases are asymptomatic (Nogrady, 2020). This means that the virus can be spread unknowingly if safety precautions are not in place (Howard, 2020). After the first case, the number of cases started growing exponentially day by day. As a result, state governments imposed stay at home orders instructing citizens to restrict their movements outside the home if not required (Mervosh et al., 2020). California was the first to declare the order on March 19, 2020 (A. Lee, 2020). By that time, more than twenty states have declared school closures (*22 States Have Closed School Statewide Because of the Coronavirus*, 2020). Within early April, most states implemented stay at home orders away from crowds to limit potential exposures to the virus. Citizens were allowed to go outside for emergency and essential requirements. However, mass gatherings like weddings and funerals were restricted for the time being (Crump, 2020). Beside intra-state movements, inter-state travel restrictions had also been enforced by local governments (Studdert et al., 2020). Against the rising number of COVID patients, restriction in intra and inter-state movements certainly played a major role in flattening the curve.

3.3 Government guidelines

COVID-19 had struck the social and corporate life of individuals badly. It is difficult to cope up with these changed circumstances. Although local and international movements were restricted, people still had to go out for grocery, medical, and financial activities (Tatham, 2020). Therefore, citizens needed proper guidance regarding their do's and don'ts. Soon after the pandemic began, the US government started spreading public awareness. The COVID-19 situation was declared as a public health emergency on January 31, 2020 (HHS Press Release, 2020). The CDC started publishing information regarding the symptoms, safety instructions, effects, disease control for individuals that the US government was recommending for all citizens (CDC, 2020b, 2020j). Government agencies started awakening citizens to wearing masks, washing hands and practicing social distancing (Center for Drug Evaluation and Research, 2020). Major grocery outlets also implemented social distancing practice by putting stickers six feet apart to assure social distancing among shoppers at stores (Barthel, 2020). Wearing masks was encouraged in public places. A public gathering of more than fifty people was discouraged by CDC (Kopecki, 2020). The US government had been quite comprehensive in instructing citizens, localities, corporate offices, and others to control the spread of COVID-19 and staying as safe as possible. The government website of the United States government accumulates those instructions and necessary links for everyone (USAgov, n.d.). They continuously update the website to provide optimum support for everyone during this pandemic.

3.4 Delay in Action

Despite all of the steps, a large portion of people thinks that the US government made a delayed response to the devastating COVID-19 (Pew Research Center, 2020). The US had not only failed to offer adequate testing, but

also lacked enough PPE for the frontline healthcare providers (Zurcher, 2020). Reports suggest that a large number of deaths could had been avoided by timely response (Sebenius & Sebenius, 2020). It is argued that the US did not take COVID-19 as seriously as needed in the early stages (Chakradhar, 2020). Also, a lack of transparency hampered prompt action (Robbins & Garde, 2020). However, no country was sufficiently prepared for such a pandemic, and the US government is no exception.

4. Management of COVID-19 data in the US

Proper management of data is very important in case of infectious diseases like COVID-19. It is always recommended to collect and utilize accurate data in such unprecedented situation (LaFaro, 2020). Data helps to evaluate existing situation, predict upcoming crisis and make influential decisions (*The Importance of Coronavirus Data Tracking*, 2020). Data scientists use collected data to visualize and see the trend which helps medical personnel and policy makers take preventive measures. As a person might get affected through community transmission without going out or meeting a patient, tracking became more vital (North Carolina Medical Board, n.d.). Therefore, reporting of COVID-19 cases and relevant information were made mandatory through surveillance and reporting (CDC, 2020c). Contact tracing was also activated to ensure public safety (CDC, 2020c). This section will cover data tracking and contact tracing in the US during COVID-19.

4.1 Data tracking

Understanding the demand of this crisis time, a number of organizations came forward in data tracking. Johns Hopkins University was one of the first with COVID-19 data tracking and gained particular attention (Datta, 2020). Beside data tracking, the Johns Hopkins website offered analysis of trends with good visualization (Johns Hopkins University & Medicine, n.d.). Some of the other initiatives are "WHO situation dashboard," "Tracking COVID 19 by HERE technology," "The Esri story maps," "Microsoft COVID 19 tracker," "Google's project baseline," "HealthMap," "University of Washington," "CDC," "KFF tracker" and many more (Datta, 2020). All of these websites maintained tracking and analyzing COVID-19 data on a global scale including for the US in real time. Good visualization and high level of interactivity have been offered to make information convenient for everyone.

Apart from these, there were other sites that focused entirely on the US. Examples of such tracking sites are "The COVID tracking project," "DATAUSA," "Tracking COVID-19 Cases in the USA by CNN," and "Coronavirus in the U.S.: Latest Map and Case Count" (DATAUSA, n.d.; Herndez et al., n.d.; The COVID Tracking Project, n.d.; The New York Times, 2020). While these websites were looking into COVID-19 cases, deaths, tests and patterns, there were other websites tracking data of PPE needs and supply. "Get Us PPE" has been an exceptional initiative, which is not only keeping PPE demand-supply information but also it is arranging PPE for those in critical need (Get Us PPE, n.d.). The website has made it possible by collecting information about people in need and people and organizations with a surplus of PPE. All these efforts suggest that the US provided useful COVID-19 data but in an almost random fashion with many different sites, mostly non-profit and non-governmental, providing daily updates.

4.2 Contract Tracing

WHO defines contact tracing as "the process of identifying, assessing, and managing people who have been exposed to a disease to prevent onward transmission" (World Health Organization, n.d.-a). Contact tracing is a excellent mean to prevent spread of COVID-19 (Harvard Health Publishing, 2021). Therefore, CDC included it in their monitoring system and gave proper instructions to the public regarding this (CDC, 2020a, 2020c). Under contact tracing when implemented well, when a person tests positive to COVID-19, the persons who came

into close contact are identified, receive a quick communication by the healthcare professionals, and then take necessary actions based on their symptoms (MAYO CLINIC, 2020). Because persons at close contact are under high risk of being infected and spreading the virus unknowingly, the person who had symptoms were asked to test for COVID-19. Others were advised to quarantine for 14 days to see if any symptoms appear. Some mobile apps were also introduced to aid the contact tracing program. "SlowCOVIDNC" is a contact tracing app that is in use to identify contacts of someone tested positive anonymously (NCDHHS, 2020). However, many feel that the US failed to fully apply effective contact tracing during COVID-19 due to funding shortages and other government priorities (Aschwanden, 2020). Lack of interest in this program was also shown publicly (McCarthy, 2020), and it appears the US failed to get full benefit of contact tracing during this pandemic.

5. Identifying the need of Healthcare Facilities

As healthcare facilities are the first service provider to patients, they need to be well prepared. This includes their resource utilization and ample preparedness. During this pandemic, the US hospitals used different tools and models to take those preparations and offer proper care. One of those tools was developed by Stanford University engineers, which contained two parts, one for predicting county-wise hospitalization and the other for PPE requirements calculations (Andrews, 2020). Based on this tool, hospitals can understand if they have enough available beds and PPE for the doctors, nurses and others. The CDC also developed an Excel tool of similar type to analyze the PPE burn rate for hospitals (CDC, 2020h). The University of Florida Health also created a PPE calculator to track, and predict PPE for healthcare facilities (AHRMM, n.d.). These tools helped healthcare system to make strategic planning about their capacity and PPE requirements ahead of time. State level dashboards helped to visualize the overall scenario of the hospital's capacity and PPE. For example, the dashboard of North Carolina as in Figure 3 presents how many beds in ICU and other units are occupied which helped in state level decision making.

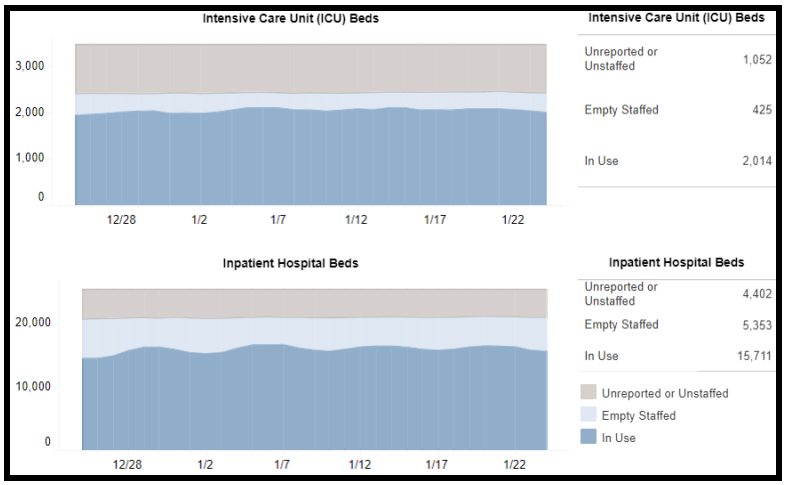

Figure 3. Graphs of in use hospital beds and ICU beds by the COVID-19 patients (NC DHHS, n.d.-a)

Also, state level PPE requirements, ordered and received numbers were kept transparent to everyone (NC DHHS, n.d.-b). Overall, a number of tools were used at organization and state level in the US during this pandemic.

6. International Examples

COVID-19 has been one of the unforeseen events for which no one was well prepared. The rapid spread perplexed health officials and governments around the world. The situation got worse with time and is still serious. Under such circumstances, governments in different countries responded differently. The challenge was not only to cure the affected ones but also to ensure prevention by increasing consciousness, social distancing and other preventive measures. Arranging PPE for the healthcare and emergency workers and the citizens has also been a crucial job for every country. Taiwan has been remarkable in fighting COVID-19 successfully and has become an example to others (C. Wang et al., 2020). United Kingdom (UK) has been prompt in battling their PPE crisis and gained quite a success (Department of Health and Social Care, 2020a). This section will highlight major steps taken by these two countries that has set examples for others.

6.1 Taiwan

Taiwan is only 81 miles off the coast of mainland China with a population of 23.5 million at a density of 651 people per square mile ("Demographics of Taiwan," 2020). Despite of being so close to the originating country of COVID-19 and having close communication with China, Taiwan has been extremely successful in managing COVID-19. They had their first COVID patient on January 21, 2020 (Taiwan, Wikipedia, 2020). By January 27, 2021 the total confirmed cases in Taiwan was only 793 with very few deaths recorded (WorldOMeter, n.d.-b). Compared to other countries, these statistics present a commendable accomplishment against the virus. Acting very early was the key to this accomplishment. Utilizing data analysis, they integrated the national health insurance database and immigration and customs database to analyze the travel history and health symptoms to prevent potential entry and spread of the virus (C. J. Wang et al., 2020). Moreover, they tracked COVID patients phone locations to make sure they remained home to stop the spread. They even called twice a day to check (Y. Lee, 2020a). They called this practice an electronic fence (Reuters, 2020a). High fines were imposed on anyone stepping outside their homes during quarantine obligations (Y. Lee, 2020b). April 12, 2020 is the last time a local Taiwanese was reported with COVID-19 (Thornton & Griffiths, 2020). The Taiwanese were successful in arranging PPE for all citizens and health workers. Initially, they banned the export of any masks and fixed the prices with set limits per person to ensure every citizen could attain the PPE needed (Wei-ting & Hsu, 2020). They also used their military to boost PPE production (Tzu-ti, 2020). As a result, they quickly became the world's second largest producer of PPE and are donating PPE worldwide. On April 1, they announced the plan to donate 10 million masks to the world's neediest countries (Jao, 2020). These methods helped Taiwan to become a role model for rest of the world during this pandemic.

6.2 United Kingdom

The United Kingdom has been one of the countries with a severe problem with containing COVID-19. They have recorded 101,887 deaths indicating the severity of the virus (WorldOMeter, n.d.-c). At the beginning of the pandemic, the country faced many shortages and distribution issues with PPE. Usually, the country has been dependent on imported PPE. Early in the pandemic a delayed and poor-quality delivery from Turkey awakened the government to the seriousness of the problem (Walker, 2020). The national stockpile was also not well prepared for the COVID pandemic (Media, 2020). As a solution, the UK government accumulated 350 domestic and 100 international suppliers to arrange more than 5.5 million PPE (Department of Health and Social Care, 2020a). Not all these companies were medical suppliers. They urged other companies to contribute producing PPE in place of their regular products, and many companies responded to the call. For example, a pest control company, PestFix, was given a contract of $137 million to produce PPE (Canter, 2020),

and many hospitals took their own initiatives. One commendable example is Wolverhampton was a hospital that created a mini-factory capable of producing 5000 visors every day in their library (Campbell, 2020). The government was trying to explore every possible opportunity by appointing devoted personnel to respond to PPE shortages. One of the chief executives of the London Olympics, Paul Deighton, was given the wheel to accelerate PPE arrangements (Reuters, 2020b). A dedicated PPE supply chain was organized to address the urgent requirements for hospitals and health care workers (*PPE Dedicated Supply Chain*, n.d.).

The proper distribution of PPE even after production has been very challenging for most governments. The United Kingdom created a dedicated PPE distribution system with the help of the army. The major tasks of this unit were storing PPE centrally and delivering the needed PPE to National Health Service (NHS) Trusts and hospital locations based on needs (Udale-Smith, 2020). The NHS-UK has done a commendable job of coordinating the hospitals' needs and providing timely delivery. They have maintained continuous communication with NHS leadership and local resilience forums (NHS-UK, n.d.). Hotlines and portals have been established to respond to urgent requirements. The government also created an invitation-only PPE portal for priority fast processing and delivery of PPE (Department of Health and Social Care, 2020b).

8. Conclusions and Recommendations

Within just more than a year, COVID-19 has changed the world. The US has been heavily impacted. Even now, with a major launch of vaccinations, the country is in one of the darkest periods of the virus. The government agencies at federal and state levels have tried implementing many different strategies during the pandemic. Critical decisions included screening at the borders, discouraging public movement, restricting public gatherings, and providing guidelines. Some areas published stay-at-home orders and used contact tracing. Additionally, the US focused on spreading knowledge about the virus and raising public awareness which inspired many residents to understand the severity of the virus and take proper measures. Technology was one of the critical components of the US COVID-19 response, which offered real-time tracking of COVID related information and helped analysts to predict trends. Initiatives from many different non-profit organizations were commendable.

Despite many efforts, the US failed to assure enough PPE for healthcare professionals. Several different software systems were created to understand the gaps between PPE requirements and supplies. These were not linked at a national level to become truly effective. Delayed responses and poor maintenance of the national stockpile created many issues that other countries appeared to handle far better. Taiwan's response and rapidly created production capacity allowed them to meet their needs quickly and become an exporter of PPE. The UK's actions showed how the PPE crisis could be battled with prompt response and collaboration. There are likely many lessons to be learned from best practices from countries around the world.

The US needs to focus on rebuilding and maintaining its Strategic National Stockpile as well as increasing domestic PPE production facilities. Current PPE requirement calculation models can be utilized to create a nationwide reporting and monitoring system. The pandemic has shown the significance of having correct , complete, and timely data. A system for accurate reporting of PPE needs from hospitals and other healthcare providers needs to be established at a national level. The US needs to have workable plan for the next pandemic.

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