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Risk Factors Associated With COVID-19 Severity Amongst Adults With Pre-existing Medical Conditions In The United States

Master Thesis

In The Department of Health Sciences

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PREFACE

It is with great pride and deep emotion that I present this master's thesis, titled "The Risk Factors Associated with COVID-19 Severity Amongst Adults with Pre-existing Medical Conditions in the United States," as part of my pursuit of a Master of Science degree in Health Sciences at the Hamburg University of Applied Sciences in Hamburg, Germany.

This thesis represents the culmination of extensive research and dedication, exploring a topic of great interest and relevance. The COVID-19 pandemic has profoundly impacted lives worldwide, particularly those individuals living with pre-existing medical conditions, who have been recorded to be at heightened risk of severe outcomes. My research journey has been driven by a fervent desire to shed light on the risk factors that exacerbate COVID-19 severity in this vulnerable population and to contribute to the development of effective public health interventions for better management of the next possible outbreak. Conducting this research has been both enlightening and challenging, as it required meticulous data analysis, extensive literature review, and a rigorous examination of epidemiological patterns. Nonetheless, the significance of this study has been the driving force behind my dedication and perseverance.

Throughout the course of this academic endeavor, I have been fortunate to receive the invaluable support, guidance, and encouragement of esteemed professors and colleagues/peers. Their unwavering belief in my capabilities and their insightful feedback have been instrumental in shaping the trajectory of this research and my growth in the field of public health. I do hope this master’s thesis will contribute meaningfully to the growing body of knowledge surrounding COVID-19 and its impact on vulnerable populations. I aspire that the insights garnered from this research will aid in shaping evidence-based policies, promoting better health outcomes, and ultimately improving lives.

Furthermore, I dedicate this master's thesis to my dad, who unfortunately passed away late last year. Your sudden departure was a profound loss that left an irreplaceable void in my heart and life. His unconditional support, love, and belief in my abilities were a constant source of inspiration and motivation. His enduring legacy will forever guide me in my pursuit of knowledge and compassion in my chosen career path. Although he is no longer here to witness this achievement, I carry his memory in every step of my journey.

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I extend my heartfelt appreciation to my family (mum and siblings) and friends who have stood by me throughout this academic pursuit, offering their unwavering encouragement and understanding during challenging times. Their presence has been a source of strength, reminding me of the value of connection and the importance of cherishing those dear to us.

Finally, it is important to highlight that while the Center for Disease Control (CDC) dataset has been utilized for this master thesis, it is worth noting that "The CDC does not take responsibility for the scientific validity or accuracy of methodology, results, statistical analyses, or conclusions presented."

As I humbly present this master's thesis, may this work stand as a reminder of the importance of understanding and addressing the health disparities faced by vulnerable populations during challenging times. I hope that the findings and insights presented herein will serve as a catalyst for the development of a better understanding of the three major points (health education, health equity, and geriatric preparedness) found to have an impact on COVID-19 disease severity.

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ABBREVIATIONS

Acute Respiratory Distress Syndrome	-	ARDS
Case Report Form	-	CRF
Center for Disease Control	-	CDC
Coronavirus Disease	-	COVID
COVID-19 Technology Access Pool	-	C-TAP
Emergency Use Authorization	-	EUA
Ear, Nose, and Throat	-	ENT
European Centre for Disease Prevention and Control	-	ECDC
Food and Drug Administration	-	FDA
Food and Drug Administration	-	FDA
Gastrointestinal	-	GI
Healthcare Worker/s	-	HCW/s
Intensive Care Unit	-	ICU
International Committee on Taxonomy of Viruses	-	ICTV
Mechanical Ventilation	-	MV
Multinomial Logistic Regression	-	MLR
Novel Coronavirus	-	nCOV
Odds Ratio	-	OR
Pre-existing Medical Conditions	-	PeMC/s
Risk Behavior/s	-	RB/s
Severe Acute Respiratory Syndrome Coronavirus	-	SARs-COV
Underlying Medical Condition/s	-	UMC/s
United States	-	US
World Health Organization	-	WHO

INTRODUCTION

GENERAL OVERVIEW

Coronavirus disease (COVID-19) is an infectious respiratory disease caused by the Sars-CoV-2 virus; a type of coronavirus discovered in 2019 (1,2). The disease has garnered significant attention and discussion over the last three years. COVID-19 was first discovered at the end of 2019 in a city called Wuhan, the capital of Central China's Hubei province. The disease was first identified as an unknown upper respiratory tract infection, and as of 1st October 2020, they were 33,842,281 confirmed cases and 1,010,634 confirmed deaths reported by the World Health Organization from 216 different countries, territories, and areas. (3,4). The onset of this outbreak presented a formidable global challenge. Due to the high transmissibility of the SARS-COV-2 virus, there has been a widespread of COVID-19 across the world since its discovery at the end of 2019. The initial perception of the COVID-19 outbreak did not anticipate its profound effects on public health, mortality rates, morbidity patterns, and economic stability. Many countries have been affected in different proportions, some worse than others. For a better understanding of the different highlights during the COVID-19 pandemic, research studies on COVID-19 and its consequences have continuously been conducted worldwide.

COVID-19 EVENTS

The first onset of pneumonia of unknown cause was recorded on December 8, 2019, in Wuhan China (5,6). There were several reports of patients who had pneumonia, in which the causation was unknown. On the 9th of January, the causative agent of the pneumonia outbreak was identified as a novel coronavirus (2019-nCOV) by the Center for Disease Control (CDC) China (5,7), and the first death from COVID-19 was recorded (8). The novel coronavirus (2019-nCOV) was properly classified as Severe Acute Respiratory Syndrome Coronavirus 2 (SARs-COV-2) by the International Committee on Taxonomy of Viruses (ICTV) on February 11, 2020, and the disease named COVID-19 by the World Health Organization (WHO) (5,9). WHO declared the COVID-19 outbreak as a Public Health Emergency of International Concern (PHEIC) on the 30th of January 2020, and on the 11th of March 2020, a pandemic (7,10). Since COVID-19 was recorded at the end of 2019 in Wuhan China, the disease has spread worldwide affecting all continents. Over one million COVID-19 cases had been confirmed as of April 4th, 2020, by the WHO (11).

The Government of Costa Rica in cooperation with the WHO and other partners on the 29th of May 2020, launched the COVID-19 Technology Access Pool (C-TAP) to aid faster, affordable, and equitable access to COVID-19 health products worldwide. Health products such as COVID-19 therapeutics, diagnostics, vaccines, etc. from various developers that facilitated the distribution of data, knowledge, and intellectual property (12). The C-TAP was a response to the WHO global Solidarity Call to Action for the management of the COVID-19 outbreak (13). After the issuance of the first quality antigen-based rapid diagnostic test for the detection of the Sars-Cov-2 virus by the WHO, a global partnership ensured the availability and affordability of 120 million tests to low- and middle-income countries, in September 2020 (14).

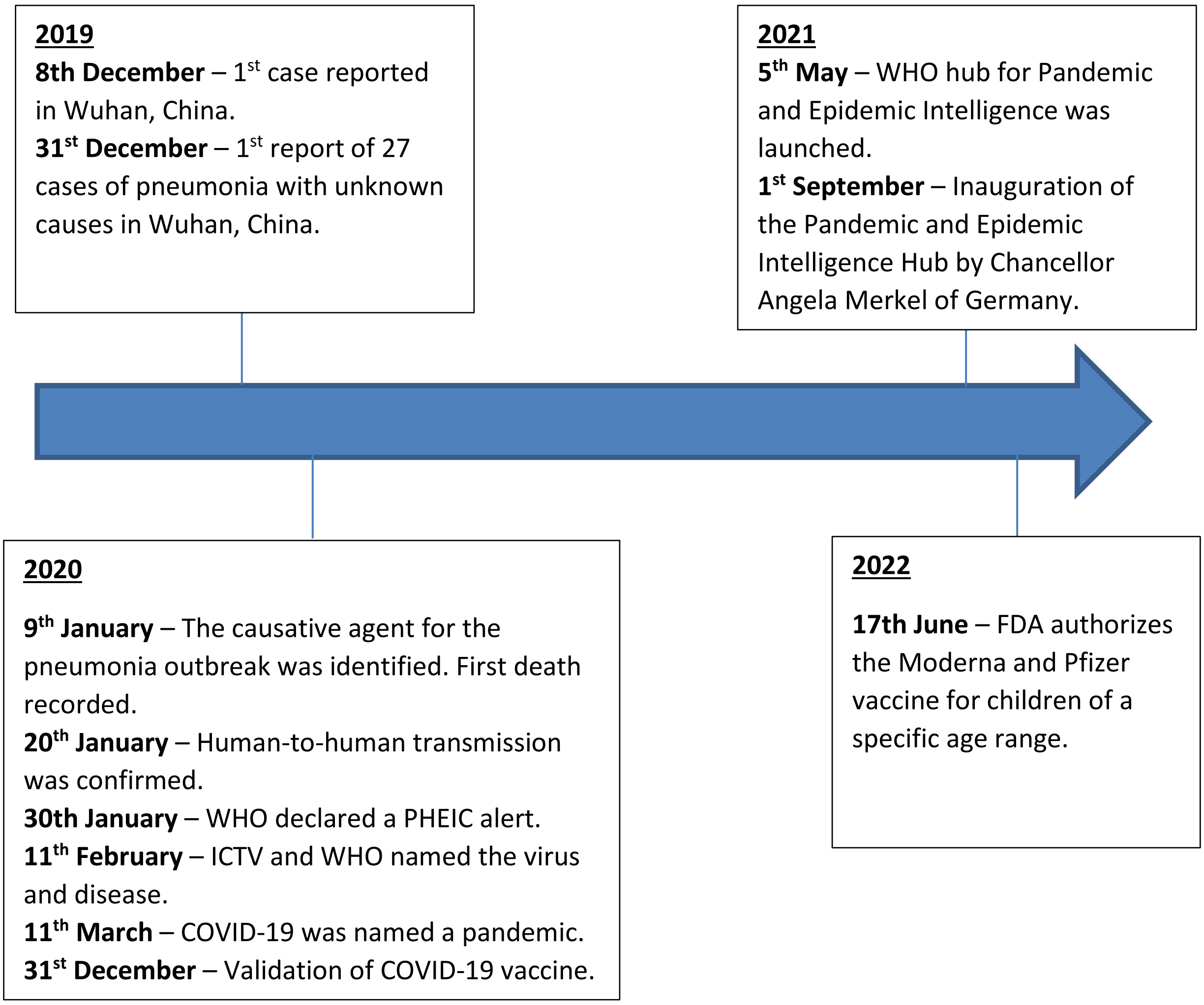

Figure 1: Key Epidemiological Events of Covid 19 Outbreak.

Approximately six months after the discovery of COVID-19, the first variant was reported in South Africa in May 2020 (15). There have been several variants of the SARs-COV-2 virus, and due to the characteristic of viruses, it was an expected event to occur. The SARs-COV-2 virus variants to date are the delta, beta, gamma, alpha, omicron, etc., with omicron being currently a circulating variant of concern by WHO as of July 2022 (15). By the end of 2020, WHO issued the first emergency use validation for a COVID-19 vaccine (16). Since the development of COVID-19 vaccines, efforts have been continuously made to ensure equitable and affordable access to vaccination (17).

COVID-19 in the United States

According to WHO COVID-19 dashboard, there are currently over 607 million cases and about 6.5 million deaths cumulatively worldwide, as of September 14^{th}, 2022, with the United States (US) representing over 15% in number of cases and 16% in deaths (18). See *Figure 2* below.

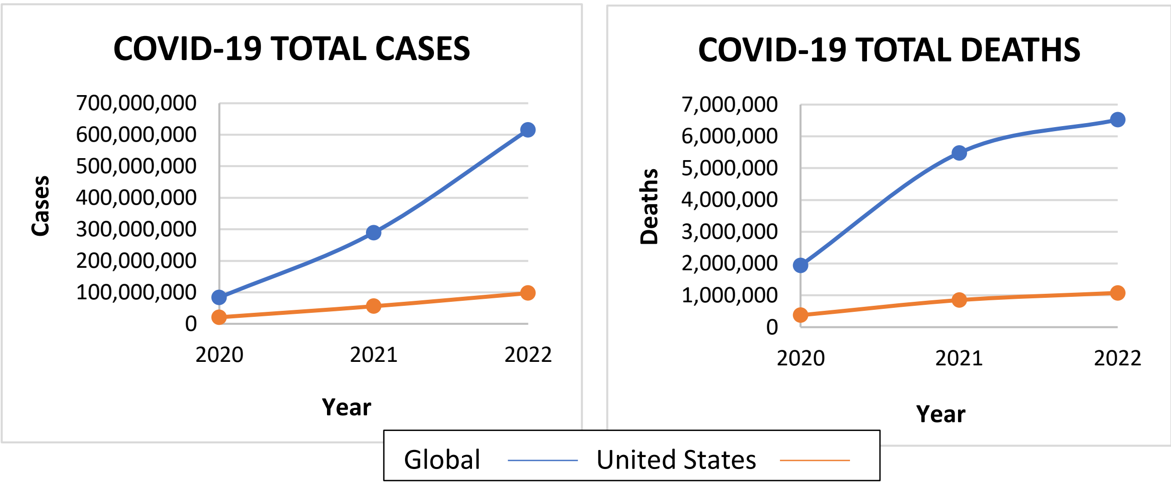

Figure 2: COVID-19 Cases and Deaths. Global vs United States

As of September 15^{th}, 2022, the US had a record of over 28,000 COVID-19 cases and over 300 deaths per 100,000 population (18). Thereby, making the US since 2020, the leading country with the highest number of cases and death worldwide. Since the world became aware of a potential disease outbreak (COVID-19) at the end of 2019, researchers have devoted time and resources to providing a wide range of information to help curb the COVID-19 disease.

COVID-19 RESEARCH TO DATE

Several research studies have been conducted on identifying the clinical outcomes and characteristics of COVID-19, various predictors influencing COVID-19 outcomes, populations with higher risk, etc. As the COVID-19 disease has shown to have various impacts on human health, from mild to critical and even death, it has been essential to identify potential factors associated with these severity levels. Data has shown the heterogeneity of the symptoms of COVID-19 disease, which has ranged from no symptoms to critical illness (19,20). Asymptomatic people can transmit the COVID-19 disease easily because they do not know that they are infected (21,22). Thereby, they go around living their life normally as they would. A wide spectrum of clinical signs and symptoms has been recorded since the onset of the COVID-19 disease. Some of the major symptoms are cough, sore throat, fatigue, dyspnea, myalgia, dizziness, etc. (20,23,24). Studies have shown diversity in clinical outcomes among patients with similar clinical characteristics and treatment strategies (24,25). The difference in clinical outcome can be mild, moderate, severe, or critical.

Research studies have shown that age (25–27), being male (26–28), and pre-existing medical conditions (PeMCs) (24,27,29,30) are factors that have been associated with clinical outcomes of high severity for COVID-19. Comorbidities such as chronic respiratory disease, cardiovascular disease, diabetes, and hypertension have been observed more frequently in patients with severe clinical outcomes (24,29,30).

Based on the wide range of research studies that have been carried out on COVID-19 since 2020, having a pre-existing medical condition has been a risk factor associated with a high disease severity outcome. However, the severity levels are heterogenous amongst individuals who present with a medical condition. The research aim is to identify other risk factors associated with the different severity of the COVID-19 disease within this subgroup in the US. The selection of the United States as the study focus was driven by its significant contribution to the cumulative count of confirmed COVID-19 cases and fatalities throughout the pandemic. Additionally, the availability of comprehensive COVID-19 data which facilitates an initial assessment of the dataset suitability for the intended research, and streamlined data accessibility were the reasons behind the selection of the US as a focal point.

RESEARCH OBJECTIVES

The following objectives have been set for this research study:

- To generate a classification approach for COVID-19 severity levels for the US CDC Dataset.
- To establish the relationship between the presence of pre-existing medical condition (PeMC) and COVID-19 severity clinical outcome.
- To assess the relationship between sociodemographic factors such as sex, race & ethnicity, and age group on the severity of COVID-19 disease.
- To determine the impact of geographic data i.e., geographical location on the severity of the clinical outcome of COVID-19.
- To analyze the effect of the seasons of the year on COVID-19 severity.
- To establish if being a healthcare worker has an impact on the severity of COVID-19 disease.
- To evaluate the relationship between the clinical symptoms of COVID-19 and the clinical outcome severity.

Research Question

The question addressed is "Predictors/Risk Factors associated with COVID-19 Severity Amongst US Adult Population with Pre-existing Medical Conditions (PeMC) Pre-Vaccination".

METHODOLOGY

During the pandemic, many healthcare departments of various countries made it a duty to collect data that would aid scientists in discovering ways and approaches to managing the pandemic. Data collected during this period has been used and it's continuously been utilized for a better understanding of the COVID-19 disease, its spread, and its management. As the purpose of this research was to investigate the risk factors associated with COVID-19 severity amongst populations with PeMCs, the dataset being collected during this period serves as a basis for analysis. After much research, the US COVID-19 dataset from the Centre for Disease Control (CDC) was found to be the most sufficient one to use for this research, as it contained various variables of interest that can be investigated for the research. The methodological approach used was the quantitative method of analysis based on the research objectives. As the research questions have not been investigated extensively yet, an exploratory approach was used for data analysis.

DATA SOURCE

The data source used for research analysis was the COVID-19 Surveillance Restricted Access Detailed Data provided by the US Centers for Disease Control (CDC) (31). COVID-19 is a mandatory condition that needs to be reported in all US state health departments, several territorial health departments, and two local health departments (New York City and the District of Columbia) (31). Information was collected using a standardized COVID-19 case report form (CRF) (32). The case report form can be found in the appendix section of this paper. The Information collected is determined by these health departments. The COVID-19 cases recorded in the dataset are confirmed based on standardized criteria. The dataset used had restricted access, therefore, an access request was first submitted, and access was granted. The dataset was downloaded from GitHub. The COVID-19 period of interest for this study was the period before COVID-19 vaccination was available for the public. As the first COVID-19 vaccination was made available for Emergency Use Authorization (EUA) by the US Food and Drug Administration (FDA) on the 11th of December 2020 (33), data used for research was filtered based on COVID-19 confirmed cases from January 2020 to December 2020. The official dataset is updated monthly in the first week.

Data Elements

The dataset contained 33 elements, however, only 27 elements from the original dataset were important for use in this research. These are:

• Initial case report date to CDC

• What is the current status of this case?

• Sex

• Age group (0–9, 10–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, 80+ years)

• Race and Ethnicity

• State of residence, County of residence, County FIPS code

• Healthcare worker status

• Pneumonia present

• Acute Respiratory Distress Syndrome (ARDS) present

• Abnormal chest x-ray (CXR) present

• Was the patient hospitalized?

• Was the patient admitted to an intensive care unit (ICU)?

• Mechanical Ventilation (MV)/intubation status

• Did the patient die as a result of the illness?

• Presence of underlying comorbidity or disease: underlying comorbidity or disease included in the dataset were both underlying medical conditions (UMCs) and risk behaviors (RBs). These included diabetes mellitus, immunosuppressive condition, hypertension, autoimmune condition, severe obesity (BMI ≥40), current or former smoker, cardiovascular disease, chronic renal disease, substance abuse or misuse, chronic liver disease, disability (neurologic, neurodevelopmental, intellectual, physical, vision or hearing impairment), chronic lung disease (asthma/emphysema/COPD), other chronic diseases, other underlying condition or risk behavior, psychological/psychiatric condition, and pregnancy.

• Presence of each of the following symptoms:

- Fever >100.4F (38ºC)
- Subjective fever (felt feverish)
- Chills
- Muscle ache (Myalgia)
- Runny nose (Rhinorrhea)
- Sore throat
- Cough (new onset or worsening of chronic cough)
- Shortness of breath
- Nausea/Vomiting
- Headache
- Abdominal pain
- Diarrhea (≥3 loose/looser than normal stools/24hr period).

STUDY POPULATION

The COVID-19 Surveillance Restricted Access Detailed Dataset contained data from populations in the United States who had both laboratory-confirmed and probable COVID-19 cases at the time data was submitted. COVID-19 cases used for analysis were before the onset of COVID-19 vaccination which was 11th December 2020. For this research purpose, the adult population (aged 20 years and above) who has a PeMC was the focus group of interest. The US adult population was distributed across different regions of the US. Personal characteristics of the study population included sex, age, race_ethnicity, location, and if they have any PeMC.

STATISTICAL ANALYSIS

The COVID-19 Surveillance Restricted Access Detailed Dataset used for analysis went through several processes such as data retrieval, data cleaning/preparation, and data analysis. During the process of data preparation/cleaning, several additional variables were created. For data collection, only data before the 11th of December 2020, and "Laboratory Confirmed" cases were extrapolated and used for analysis.

Laboratory-confirmed COVID-19 cases were defined as those cases in which Sars-CoV-2 RNA was detected in a clinical specimen using a molecular amplification detection test or by gene sequencing.

The dataset consisted of 112,957 rows. For statistical analysis, IBM SPSS Statistics 27 and 29 were used. A descriptive analysis was conducted for COVID-19 severity level, hospitalization, and death. This was followed by a multinomial logistic regression (MLR) to establish that the dataset used also agreed with the research statement that individuals with PeMC were more likely to have a higher COVID-19 severity outcome. Afterward, descriptive analysis was conducted to have an overview of the distribution of variables of interest amongst individuals with PeMC. Lastly, MLR was conducted to analyze the relationship between the predictor variables of interest and the COVID-19 severity level within this subpopulation. The additional variables created for the research purpose are listed below:

Season of the year

The dataset provided information on the earliest date of COVID-19 confirmation, as this was one of the research objectives. The dates were categorized based on the seasons of the year; Winter (December, January, February), Spring (March, April, May), Autumn/Fall (September, October, November), and Summer (June, July, August). Data will be used to analyze if there is a relationship between the seasons of the year and COVID-19 severity.

Geographical Location

The CDC dataset included information on residence county codes, residence county, and county state of the study population. Location was further categorized based on the regions of the United States (South, Northeast, Mid-West, and West). However, the US region's South was merged into the region "West" and Northeast to Mid-west for the data analysis for this master thesis. The reason behind the merging of regions, was due to very low distribution frequencies of COVID-19 cases in the dataset for the Southern and Northeast regions, as this affected the logistic regression analysis.

Race and Ethnicity

The study population was of several races, namely: American Indian/Alaska Native, Asian, Black, Native Hawaiian/Other Pacific Islander, White, and Multiple/Other. While ethnicity was categorized into Hispanic and Non-Hispanic. Data from both variables were combined to provide insight based on both race and ethnicity of the study population.

Age

As the focus of this research was on the adult population with PeMCs, age was categorized based on the following:

- Young Adult (20-39yrs)
- Middle-aged Adult (40-59yrs)
- Older Adult (≥60yrs)

COVID-19 Clinical Characterization

It was important to differentiate between clinical symptoms and clinical complications of COVID-19, in other to correctly identify characteristics that were associated with the severity of COVID-19. Clinical symptoms of COVID-19 present in the dataset used were:

- Fever >100.4F (38°C)
- Subjective fever (felt feverish)
- Chills
- Muscle ache (Myalgia)
- Runny nose (Rhinorrhea)
- Sore throat
- Cough (new onset or worsening of chronic cough)
- Shortness of breath (dyspnea)
- Nausea/Vomiting
- Headache
- Abdominal pain
- Diarrhea (≥3 loose/looser than normal stools/24hr period).

The following were classified as clinical complications of COVID-19:

- Pneumonia
- Abnormal Chest X-ray
- ARDS
- MV/Intubation

A new variable based on the presence of COVID-19 clinical symptoms was created to have an overview of persons who were symptomatic and asymptomatic. The new variable was categorized based on the clinical symptoms of COVID-19, while another variable was created based on the presence of COVID-19 clinical complications. Subsequently, a new variable was created based on the total number of clinical symptoms and complications for each individual. The clinical symptoms for the new variable were based on grouping the clinical symptoms based on the human body systems.

Table 1: Classification of COVID-19 Clinical Symptoms Based On Human Body Systems

Human Body System	**Clinical Symptom**
General Symptom	Fever, subjective fever, chills
Neurological Symptom	Muscle aches (myalgia), headache
Respiratory Symptom	Cough, shortness of breath (dyspnea)
Ear, Nose, and Throat (ENT) Symptom	Runny nose, sore throat
Gastrointestinal (GI) Symptom	Diarrhea, nausea/vomiting, abdominal pain

COVID-19 Severity Scale

There are several classifications for the severity of COVID-19 provided by different public health institutions. These institutions include the World Health Organization (WHO) (34), European Centre for Disease Prevention and Control (ECDC) (35), and several published research papers (20,36–38). Based on the information and guideline provided by these sources, a COVID-19 severity scale was developed per the variables available for analysis.

Table 2: COVID-19 Symptom Severity Scale

Severity Scale	Classification
0	Asymptomatic
1	Mild to Moderate
2	Severe
3	Critical

Asymptomatic: Individuals who had no clinical symptoms of COVID-19 or developed any COVID-19 clinical complications. Use of MV, ARDS, Pneumonia, and Abnormal Chest X-ray were not considered clinical symptoms, but clinical complications of COVID-19. Therefore, these were not included under "clinical symptoms" of COVID-19.

Mild to Moderate: Individuals who were symptomatic, but did not present with dyspnea, or any of these clinical complications of COVID-19 (Pneumonia, Abnormal Chest X-ray, ARDS, MV).

Severe: Individuals who were symptomatic, presenting either with dyspnea or pneumonia, or abnormal chest X-ray, with no ARDS or MV.

Critical: Individuals who either presented ARDS or were on a MV or were admitted to the ICU.

For research analysis, "death" and "hospitalization" were not considered as baseline severity.

Pre-Existing Medical Condition as a Risk Factor

MLR was conducted to establish a cause-effect relationship between the presence of PeMC and the severity level of COVID-19. Preceding conducting the MLR, all variables of interest were checked to meet the necessary assumptions. All assumptions fitting to the variable of interest were met. After a significant relationship was established between PeMC and the COVID-19 severity level variable, the dataset was filtered by restricting the dataset to patients who responded positively to having a PeMC. The restriction method was used for accounting PeMC as a confounder.

RESULTS

As it was necessary to establish that a cause-effect relationship was present between having a PeMC and the COVID-19 severity level created, a multinomial logistic regression (MLR) was carried out. Before conducting MLR, descriptive analysis was conducted for COVID-19 severity level, hospitalization, and death variable. Data used for analysis consisted initially of 112,957 rows. After confirmation of the relationship between the above-mentioned variables, the study continued with the subpopulation of individuals with PeMC. Descriptive analysis was conducted to have an oversight on the main features of the subgroup of interest, and subsequently, MLR to study the relationship between other predictor variables of interest and the severity level of COVID-19 disease.

GENERAL DESCRIPTIVE ANALYSIS

COVID-19 severity levels

An individual severity scale was designed based on the information available in the numerous scientific studies that have been carried out. The dataset used showed that 10.8% of the general population were asymptomatic (no clinical symptoms present), 59.7% had "mild to moderate" severity, 26.9% were classified as "severe," and 2.6% were critically ill. From the general population, 9208 (8.2%) were hospitalized, and 1708 (1.5%) died. As "hospitalization" and "death" were not used as baseline severity, the recorded percentages for COVID-19 severity are listed respectively. Of the 8.2% of individuals who were hospitalized, 6.2% were asymptomatic, 19.1% were "mild to moderate", 46.7% severe, and 28.0% critical. Of individuals who died (1.5%), 11.7% were asymptomatic, 20.7% "mild to moderate," 25.6% severe, and 42.0% critical severity.

MULTINOMIAL LOGISTIC REGRESSION (MLR)

PeMC and COVID-19 Severity Level

As the main study focus was individuals with PeMCs, 54,462 (48.2%) belonged to this group. The rest of the population 58,495 (51.8%) did not record any PeMCs. Descriptive analysis was first conducted to have an overview of the characteristics of the dataset based on these two variables (PeMC and COVID-19 severity) in the general population.

Of the 10.8% of the population who were asymptomatic, 49.2% had some type of PeMC, while 50.8% had none. For individuals with mild to moderate severity, 42.1% had a medical condition, while 57.9% did not. For the population group who presented with severe severity, 57.9% had a medical condition, while 42.1% had none. The critical group had 85.0% with a medical condition, and 15.0% without.

Table 3: Analysis of PeMC Variable Based on COVID-19 Severity Level

		Asymptomatic		Mild to Moderate		Severe		Critical	
Pre-existing medical conditions?	Yes	6012	(49.2%)	28395	(42.1%)	17582	(57.9%)	2473	(85.0%)
	No	6219	(50.8%)	39080	(57.9%)	12761	(42.1%)	435	(15.0%)

To establish the first hypothesis that PeMC was a risk factor for COVID-19 severity as seen in several research papers, a MLR was done to confirm this for the data in use. The reference category chosen was "mild to moderate" for the dependent variable "COVID-19 Severity Level". The "mild to moderate" category was chosen as the reference category because it was the normative category and the largest category in the dataset for the dependent variable (COVID-19 severity level). Before analysis, multinomial logistic regression assumptions were checked and were met.

The "Model Fitting Information" table contained a Likelihood Ratio chi-square test, comparing the presence of the PeMC variable as a predictor against the absence of a predictor. Statistical significance indicates that the predictor variable analyzed shows a significant improvement [$x^2(3) = 3904.913$, $p<.001$] in fit over the null model (intercept only). The Likelihood Ratio Test shows a significant association ($p<.001$) between the PeMC variable and the severity level of COVID-19 in the population.

The "Parameter Estimates" table below shows the comparison between individuals who presented with either "Asymptomatic," "Severe," or "Critical" levels of COVID-19 severity against those with "Mild to Moderate" COVID-19 severity. MLR showed that individuals with PeMCs compared to those without a PeMC were more likely to have a COVID-19 severity level of "Asymptomatic" (B = 0.286), "Severe" (B = 0.640), or "Critical" (B = 2.057) than "Mild to Moderate".

For a more meaningful interpretation, the odds ratio (OR) is used as indicated as Exp(B) in *Table 4*. Results showed that the odds of COVID-19 severity level being asymptomatic, severe, or critical rather than "mild to moderate" were 33.0% (OR=1.330), 89.6% (OR=1.896), and 679.4% (OR=7.824) respectively, higher for individuals with PeMC than for those without any PeMC.

Table 4: Multinomial Logistic Regression Analysis for COVID-19 Severity Level and PeMC as a Predictor

COVID19 Severity Level		**Sig.**	**Exp(B)**	**95% CI**
Asymptomatic	PeMC? =Yes	<.001**	1.330	1.280-1.383
Severe	PeMC? =Yes	<.001**	1.896	1.845-1.949
Critical	PeMC? =Yes	<.001**	7.824	7.058-8.674

*$P<0.05$ **$P<0.01$

From the MLR analysis carried out above, it can be proven that the presence of PeMC was significantly associated with the severity level of COVID-19 in the population. Having established the relationship between the two variables, the dataset was restricted to individuals with PeMC as a method for adjusting for PeMC as a confounder. There were 54,462 data analyzed from the PeMC variable restriction. As this relationship has been established between PeMC and COVID-19 severity levels, a descriptive analysis of the subpopulation of interest was conducted.

STUDY-SPECIFIC DESCRIPTIVE ANALYSIS

Sociodemographic Characteristics

The subpopulation consisted of 23,540 (43.2%) males and 30,992 (56.8%) females. The males comprised 24.9% young adults, 37.0% middle-aged adults, and 38.1% older adults. Of the females, 28.9% were young adults, 36.8% were middle-aged adults, and 34.3% were older adults. Furthermore, the largest population represented by the dataset were Whites (71.7%), followed by Blacks (12.7%), then Hispanic/Latino (10.3%). The Asian population represented 1.6% of the dataset, 0.5% Native Hawaiian/Other Pacific Islander, 0.2% American Indian/Alaska Native, and 3.0% Multiple/Other. Those who were of Latino/Hispanic ethnicity were categorized together as a group regardless of their race.

Geographical Location

In terms of geographical location, 85.0% of the population was from the Mid-west region (consisting of the mid-west and northeast region) and 15.0% from the West (consisting of the west and south).

Season of the Year

Dataset also showed that only 7.9% of COVID-19 incidence was recorded in the winter season, 19.0% in spring, 42.5% in the autumn/fall, and 30.6% in the summer.

Healthcare Worker (HCW)

Healthcare workers ranged from physicians, respiratory therapists, nurses, environmental services, and other healthcare professionals who were employed in healthcare facilities such as hospitals, nursing homes/assisted living centers, long-term care centers, rehabilitation centers, and others. For the study population, 14.2% were healthcare workers while 85.8% had other non-healthcare professionals. Of the 14.2% who were HCWs, 14.3% were males and 85.7% were females. Within this group, they were 41.2% young adults, 46.4% middle-aged adults, and 12.4% old adults.

COVID-19 Clinical Symptoms

To have a first overview of the distribution of symptoms of COVID-19 in the study population, a new variable was computed based on the presence vs absence of COVID-19 clinical symptoms. The dataset showed that 11.4% of the study population was asymptomatic, while 88.6% experienced some sort of COVID-19 symptom. The five most recorded COVID-19 clinical symptoms were cough (64.8%), headache (55.0%), muscle ache (myalgia) (54.3%), chills (42.2%), and subjective fever (41.5%). *Table 5* below shows a detailed insight into the distribution of the COVID-19 symptoms in the study population. Based on the classification of the COVID-19 clinical symptoms of the human body systems, 61.3% of the study population had a general symptom, 69.1% had a neurological symptom, 70.3% had a respiratory symptom, 50.7% had an ENT symptom, and 44.6% presented a GI symptom.

In general, of the 88.6% symptomatic persons 9.3% had only one clinical symptom, 14.7% presented with two symptoms, 20.8% with three symptoms, 24.2% with four symptoms, and 19.6% had all five symptoms for the human body system clinical symptom classifications.

Table 5: Descriptive Analysis of COVID-19 Clinical Symptoms

COVID-19 Clinical symptom	**Yes (%)**
Fever >100.4F (38C)	20598 (37.8%)
Subjective fever (felt feverish)	22602 (41.5%)
Chills	22991 (42.2%)
Muscle aches (myalgia)	29562 (54.3%)
Headache	29947 (55.0%)
Cough (new onset or worsening of chronic cough)	35315 (64.8%)
Shortness of breath (dyspnea)	18218 (33.5%)
Runny nose (rhinorrhea)	19903 (36.5%)
Sore throat	17582 (32.3%)
Diarrhea (≥3 loose/looser than normal stools/24hr period)	16782 (30.8%)
Nausea or Vomiting	13737 (25.2%)
Abdominal pain	7699 (14.1%)

Further descriptive analysis was conducted to have insight into the distribution frequency of several variables based on sex, age group, and both sex and age group together. Figure 3 below showed that females had a higher distribution frequency in all COVID-19 clinical symptoms than males. Twelve clinical symptoms were present in the CDC dataset used in the study. The graphs also focused on only the response "yes" for these variables.

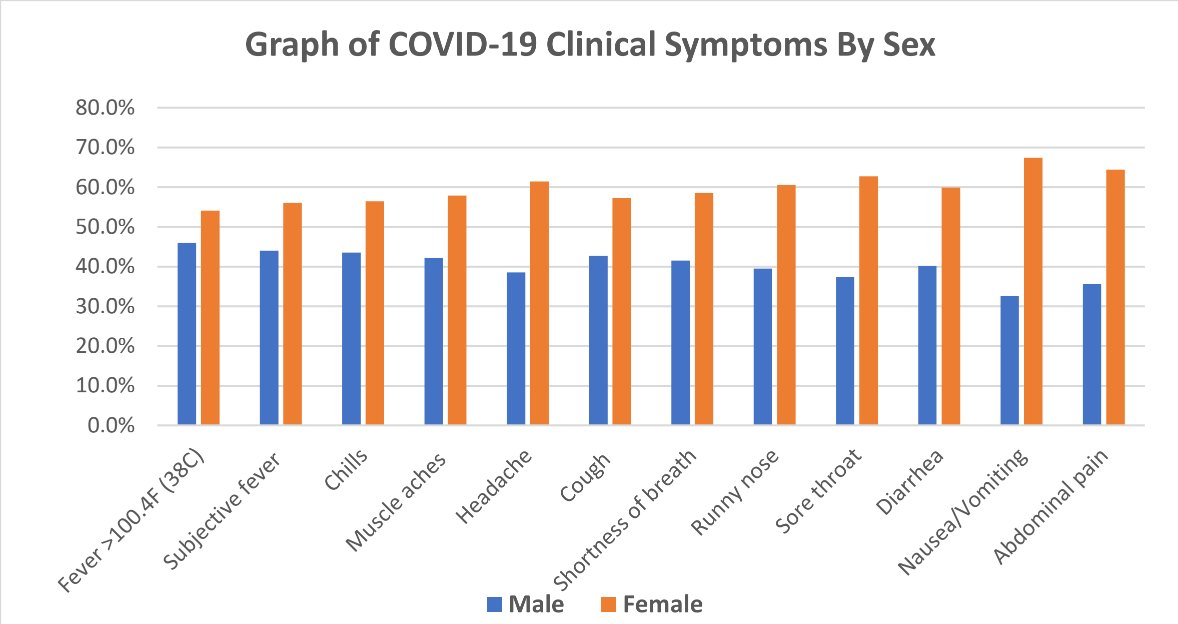

Figure 3: Descriptive Analysis of COVID-19 Clinical Symptoms Based on Sex

Descriptive analysis showed that middle-aged adults presented with a much higher frequency when compared to young adults and older adults in terms of COVID-19 clinical symptoms. These distributions can be found in Figure 4 below.

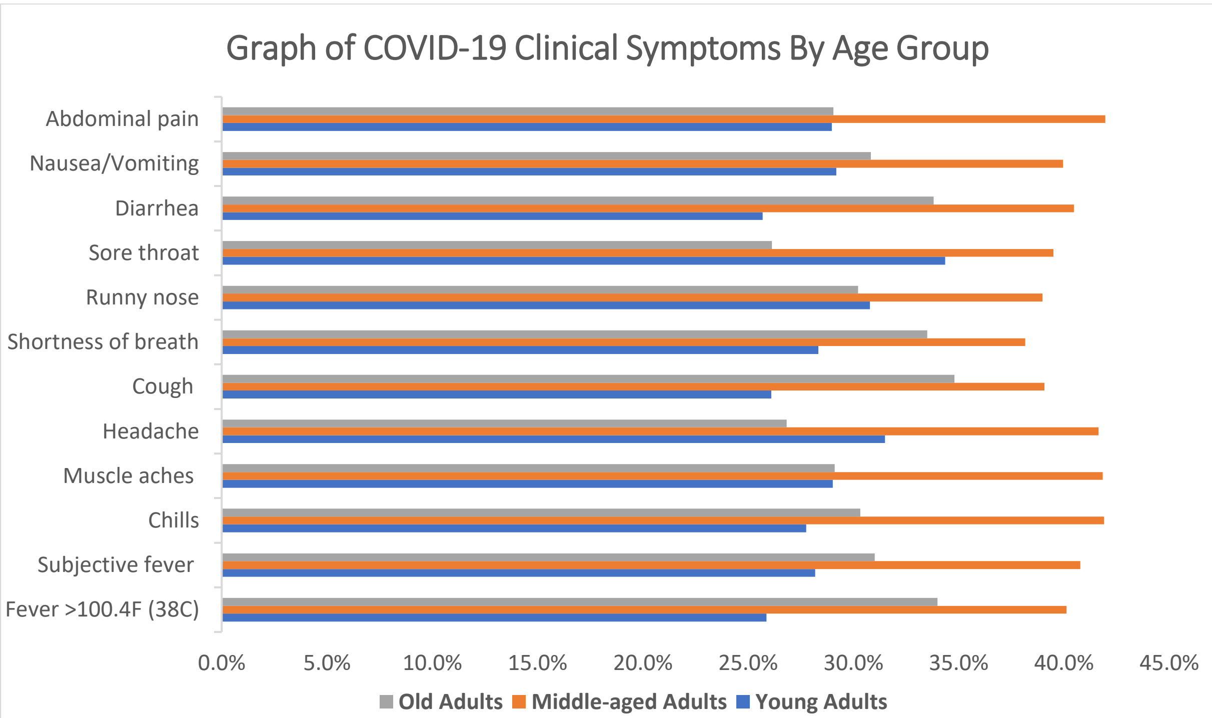

Figure 4: Descriptive Analysis of COVID-19 Clinical Symptoms Based on Age Group Categorization

Frequency distribution shown in Figure 5 of COVID-19 clinical symptoms for sex and age group categorization recorded that middle-aged males had the highest frequency for almost all clinical symptoms present in the study dataset. However, shortness of breath (dyspnea) was found to be highest amongst older male adults (39.1%) than middle-aged adults (37.3%) and young adult males (23.6%). Furthermore, young adult males (32.2%) showed a higher frequency of having a sore throat than older male adults (28.7%), but lower than middle-aged adult males (39.0%). For females, those of middle age recorded the highest distribution of COVID-19 clinical symptoms compared to young or older adults. The result did not provide new information for this study; a graphical presentation was not included.

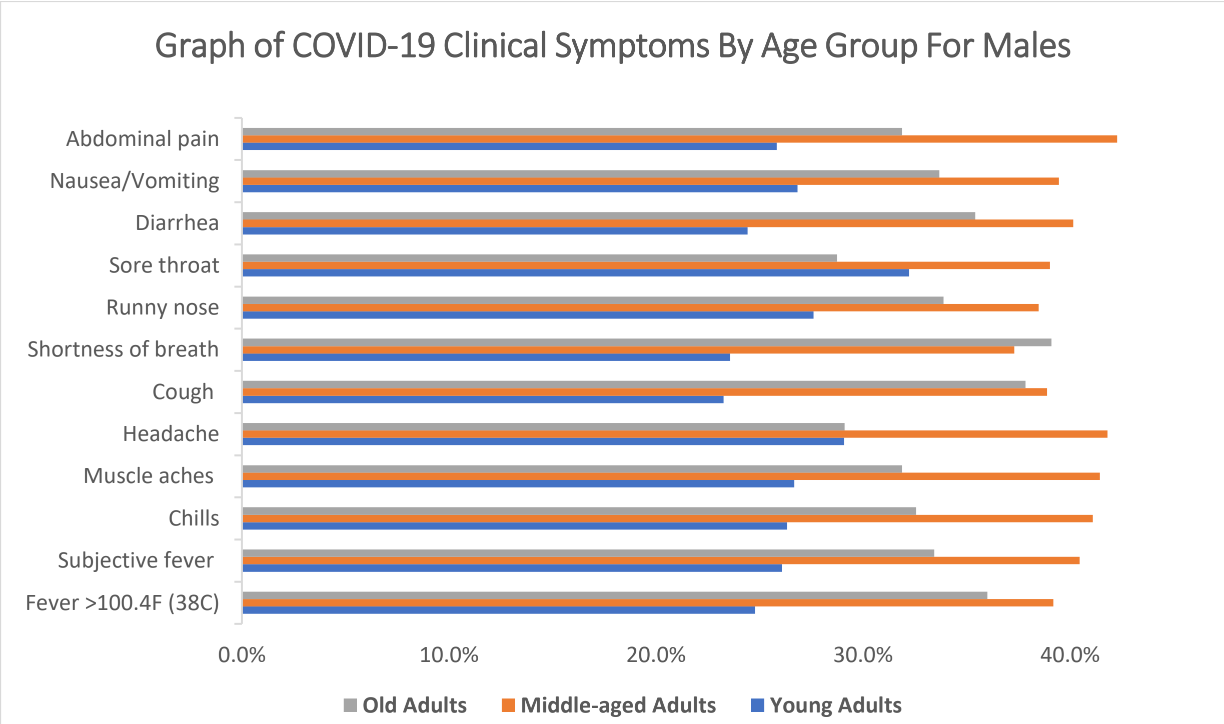

Figure 5: Descriptive Analysis of COVID-19 Clinical Symptoms Based on Age Group for Males

COVID-19 Clinical Complications

The study population showed that 10.8% developed clinical complications such as ARDS, pneumonia, abnormal chest x-ray, or received MV during their time of sickness. 8.4% of the study population developed pneumonia, 8.8% had an abnormal chest x-ray, 2.5% had ARDS, and 1.3% had received MV. From this population, 3.5% had one clinical complication, 5.2% developed two clinical complications, 1.4% had three clinical complications, and 0.7% developed all four clinical complications.

Data showed that not all clinical complications developed from clinical symptoms. They were individuals who developed clinical complications of COVID-19 without having any recorded clinical symptoms of COVID-19. Therefore, distribution was investigated for sociodemographic factors in the study. As seen in *Table 6* below, males consistently showed a higher occurrence of clinical complications than females. For symptomatic persons, minority groups had a higher occurrence frequency than those who are Caucasians (White) for disease progression within their respective population.

Table 6: Descriptive Analysis Based on Clinical Symptoms and Complications

Variable		**Symptomatic**		**Asymptomatic**	
		Clinical Complication		**Clinical Complication**	
		Yes (N%)	No (N%)	Yes (N%)	No (N%)
Sex	Male	2937 (14.1%)	17857 (85.9%)	82 (3.0%)	2664 (97.0%)
	Female	2810 (10.2%)	24656 (89.8%)	79 (2.3%)	3377 (97.7%)
Age group	Young Adults	715 (5.4%)	12591 (94.6%)	15 (1.0%)	1486 (99.0%)
	Middle-aged Adults	1895 (10.3%)	16493 (89.7%)	26 (1.5%)	1667 (98.5%)
	Old Adults	3137 (18.9%)	13429 (81.1%)	120 (4.0%)	2888 (96.0%)
Race_Ethnicity	American Indian/Alaska Native	12 (15.8%)	64 (84.2%)	1 (7.1%)	13 (92.9%)
	Asian	120 (14.2%)	725 (85.8%)	1 (2.2%)	44 (97.8%)
	Black	1026 (17.2%)	4929 (82.8%)	29 (3.0%)	952 (97.0%)
	Hispanic/Latino	731 (14.1%)	4454 (85.9%)	7 (1.6%)	419 (98.4%)
	Native Hawaiian/Other Pacific Islander	43 (18.5%)	190 (81.5%)	1 (5.3%)	18 (94.7%)
	White, Non-Hispanic	3669 (10.6%)	30820 (89.4%)	116 (2.6%)	4425 (97.4%)
	Multiple/Other	146 (9.9%)	1331 (90.1%)	6 (3.4%)	170 (96.6%)

Descriptive analysis was further conducted to have an additional insight into the distribution frequency of several variables based on sex, age group, and both sex and age group together for clinical complications of COVID-19. Figure 6 showed males to have a higher frequency distribution of COVID-19 clinical complications than males. Four clinical complications of COVID-19 were investigated.

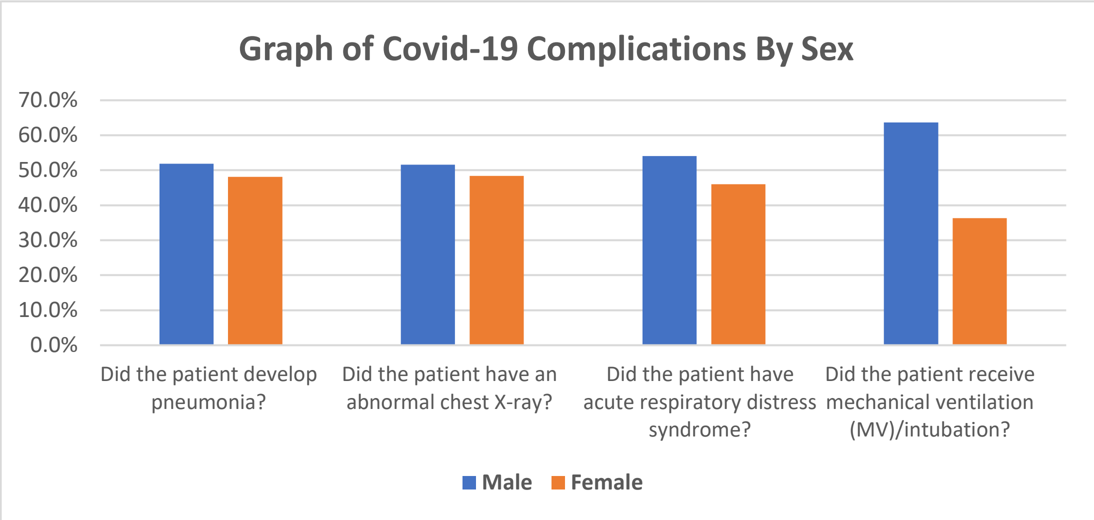

Figure 6: Descriptive Analysis of COVID-19 Clinical Complications Based on Sex

For COVID-19 clinical complication distribution based on age group, older adults were found to have a higher distribution than middle-aged and young adults. See Figure 7 below.

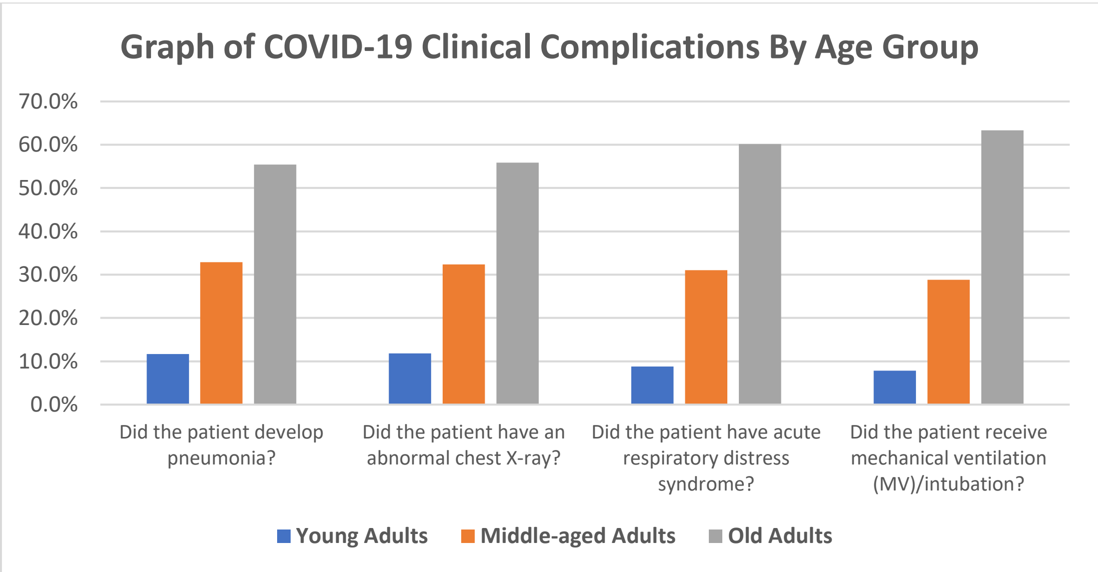

Figure 7: Descriptive Analysis of COVID-19 Clinical Complications Based on Age Group Categorization

In terms of the descriptive analysis of COVID-19 clinical complications based on age group and sex, this did not provide any new information, as data showed in both males and females, that older adults had a higher frequency of all four clinical complications. Therefore, a graphical overview was not presented.

Hospitalization and Death

Among the 54,462 individuals presented in the dataset, 7,485 (13.7%) were hospitalized, of which 13.9% died. 2.9% (1,560) of the study population died, and for this group, 32.2% were admitted to the ICU, 15.6% had pneumonia, 15.2% had abnormal chest X-rays, 32.7% recorded ARDS, and 55.6% were on mechanical ventilation. The dataset also showed that 1,765 (3.2%) underwent critical care (ICU), of which 97.1% were hospitalized, 32.2% died, 68.6% had pneumonia, 70.2% had abnormal chest X-rays, 40.3% ARDS, and 38.1% MV. A descriptive analysis was conducted to have insight into the distribution frequency of hospitalization, ICU admission, and death based on sex, age group, and for both sex and age group together.

The result of the descriptive analysis shown in Figure 8 below showed males to have had higher ICU admission and death than females. Males also had higher hospitalization rate than females, however, distribution was shared equally between both sexes.

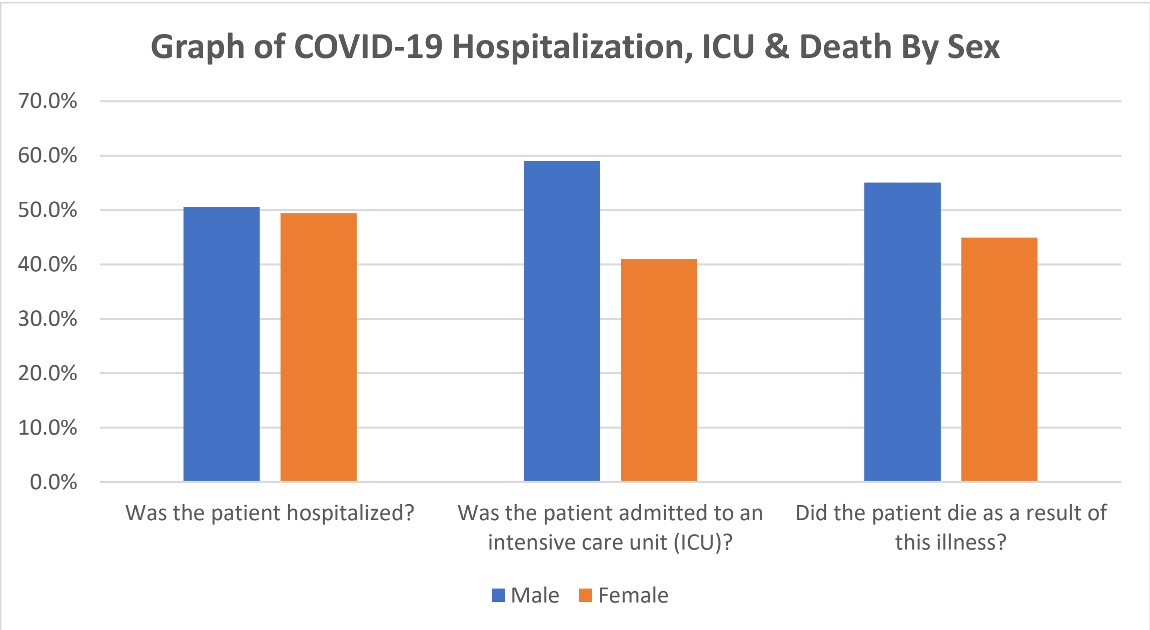

Figure 8: Descriptive Analysis of COVID-19 Hospitalization, ICU & Death Based on Sex

For the descriptive analysis based on age groups, old adults showed higher frequency distribution for hospitalization, ICU admission, and death, than young and middle-aged adults as shown in the Figure 9 below.

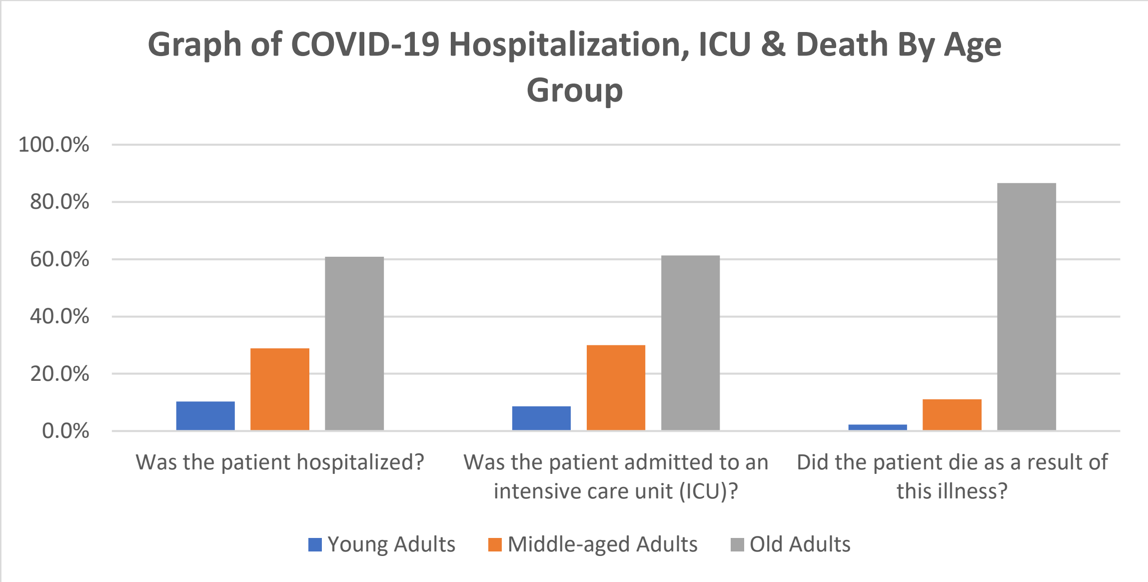

Figure 9: Descriptive Analysis of COVID-19 Hospitalization, ICU & Death Based on Age Group

Frequency distribution based on both sex and age group did not provide any additional new information, as old adults had the highest frequency regardless of sex for COVID-19 hospitalization, ICU admission, and death.

COVID-19 Severity Level

From the study population of interest, 6,012 (11.0%) were asymptomatic, 28,395 (52.1%) mild to moderate, 17582 (32.3%) severe, and 2,473 (4.5%) critical. Frequency distribution was done for these variables, sex, age group, US regions, hospitalization, and death. Males showed lower frequency than females in almost all severity levels except in the critical level where they recorded a higher frequency. The US region "west" had lower frequency across all severity levels than the "mid-western" region. Individuals who were hospitalized were higher within the asymptomatic than mild to moderate severity groups, while for death, they recorded higher distribution than "mild to moderate" and severe disease severity. *Table 7* below shows these distributions in detail.

Table 7: Descriptive Analysis of COVID-19 Severity Levels

Variable		Asymptomatic	Mild to Moderate	Severe	Critical
Sex	Male	44.1%	43.6%	40.5%	56.1%
	Female	55.9%	56.4%	59.5%	43.9%
Age group	Young Adults	24.6%	27.9%	29.3%	9.6%
	Middle-aged Adults	27.6%	38.5%	38.2%	30.9%
	Old Adults	47.7%	33.5%	32.5%	59.5%
US State Regions	West	13.1%	13.2%	16.6%	28.8%
	Mid-west	86.9%	86.8%	83.4%	71.2%
Hospitalized?	Yes	7.7%	4.5%	19.9%	91.3%
Death?	Yes	3.2%	1.0%	2.3%	27.8%

STUDY-SPECIFIC MULTINOMIAL LOGISTIC REGRESSION (MLR)

Multinomial logistic regression (MLR) was used to analyze the relationship between the following variables listed below on the probability of the severity of COVID-19 disease.

- Season of the year
- US State Regions
- Sex
- Age group
- Race + Ethnicity (Race_Ethnicity)
- Healthcare worker
- Fever >100.4F (38C)
- Subjective fever (felt feverish)
- Chills
- Muscle aches (myalgia)
- Headache
- Cough (new onset or worsening of chronic cough)
- Runny nose (rhinorrhea)
- Sore throat
- Diarrhea (≥3 loose/looser than normal stools/24hr period)
- Nausea or Vomiting
- Abdominal pain

All variables used for the COVID-19 severity scale classification were not included in the MLR analysis, as this would affect the direction of the statistical output. The following results are the statistical output provided after the MLR analysis. *Table 8 & Table 9* below shows an overview of the MLR result carried out.

SOCIO-DEMOGRAPHIC FACTORS

Sex

Asymptomatic: No significant relationship was established between sex and COVID-19 severity for this group.

Severe: The variable “sex” showed a negative significant relationship. Males were found to be 4.7% (*P*=0.023, OR 0.953, CI=0.914-0.993) less likely than women to be severe than “mild to moderate”.

Critical: Males were found to be 40.6% (*P*<0.001, OR 1.406, CI=1.286-1.538) more likely than females to be critical when compared to “mild to moderate” severity.

Age Group

Asymptomatic: Data showed that young adults and middle-aged adults were 123.5% (*P*< 0.001, OR 2.235, CI=1.709-2.923) and 88.6% (*P*<0.001, OR 1.493, CI=1.493-2.382) more likely to be asymptomatic than “mild to moderate” when compared to the older adults.

Severe: Middle-aged adults were found to be 12.6% (*P*<0.001, OR 0.874, CI=0.833-0.918) less likely than old adults to present with severe than “mild to moderate” outcomes. No significance was recorded for young adults.

Critical: Data showed that both young and middle-aged adults were 81.5% (*P*<0.001, OR 0.185, CI=0.159-0.214) and 57.5% (*P*<0.001, OR 0.425, CI=0.384-0.470) respectively less likely when compared to old adults to present with critical than “mild to moderate outcome.

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Matriculation number: [redacted]

Race and Ethnicity

Asymptomatic: No significant relationship was established between "race and ethnicity" and COVID-19 severity for this group.

Severe: There was both a negative and positive significant association between the "race and ethnicity" variable and the dependent variable "COVID-19 severity level". For this group, being "Asian" or "Hispanic/Latino" were negatively significant, while being "Black" had a positive significant relationship when compared to those who were "white." Individuals who were Asians or Hispanic/Latino were 26.0% (*P*= 0.002, OR 0.740, CI=0.611-0.896) and 17.8% (*P*=0.003, OR 0.822, CI=0.721-0.936) respectively, less likely than those who were White to have a severe clinical outcome than "mild to moderate". While those who were Black had a 22.1% (*P*= 0.002, OR 1.221, CI=1.077-1.384) more likelihood than those who were White to have a severe clinical outcome than "mild to moderate". No significant relationship was found for individuals who were American Indian/Alaska Native, Native Hawaiian/other Pacific Islander, and those who were of multiple/other race/ethnicity.

Critical: The following race/ethnicity Black and Native Hawaiian/other Pacific Islander showed a significant association in comparison to their White counterpart. Being Black showed a 116.9% (*P*<0.001, OR 2.169, CI=1.575-2.988) and Native Hawaiian/other Pacific Islander 93.4% (*P*=0.022, OR 1.934, CI=1.100-3.401) more likelihood than those who were White to have critical than "mild to moderate" clinical outcome.

There was no significance for being American Indian/Alaska Native, Asian, Hispanic/Latino, and those of Multiple/other race/ethnicity.

SEASONALITY DATA

Season of the year

Asymptomatic: No significant relationship was established between the seasons of the year "Winter" and "Autumn/Fall" and COVID-19 severity when compared to the summer season. However, a significant relationship was established between the season of the year "Spring" (*P*=0.011, OR 0.733, CI=0.578-0.930). The result showed that COVID-19 infections recorded during this season were 26.7% less likely to be asymptomatic than "mild to moderate".

Severe: The Autumn/Fall seasons was found to be not significant in comparison with cases during the summer for individuals who had severe covid-9 outcome, compared to those with "mild to moderate" severity. The "Winter" and "Spring" seasons were found to be significantly associated with the severity outcome of the COVID-19 disease.

COVID-19 infections recorded in the spring season were found to be 44.1% (P<0.001, OR 1.441, CI=1.360-1.528) more likely, while those recorded in the winter season were 7.9% (P=0.045, OR 0.921, CI=0.849-0.998) less likely than in the summer season to be severe than "mild to moderate".

Critical: All three seasons (winter, spring, autumn/fall) were found to be significantly association (both negatively and positively) with COVID-19 severity. COVID-19 infections recorded in the winter and autumn/fall seasons were found to be 75.4% (P<0.001, OR 0.246, CI=0.184-0.329) and 40.8% (P<0.001, OR 0.592, CI=0.572-0.666) less likely than in the summer to be of a critical severity level than "mild to moderate" respectively. However, COVID-19 infections recorded in the spring season, showed a 110.0% (P<0.001, OR 2.100, CI=1.888-2.335) more likelihood than those recorded in the summer to be critical than "mild to moderate".

GEOGRAPHICAL LOCATION

US State Region

Asymptomatic: No significant relationship was established between the regions in the US and COVID-19 severity for this group.

Severe: For severe COVID-19 outcome, those from the "West" of the US were found to be 29.4% (P<0.001, OR 1.294, CI=1.215-1.378) more likely than those from the Mid-west to be severe than "mild to moderate".

Critical: The critical severity was found to be 93.5% (P<0.001, OR 1.935, CI=1.731-2.164) more likely in individuals from the western region of the US than those from the mid-west when compared to the severity level "mild to moderate".

OCCUPATIONAL FACTOR

Healthcare Worker (HCW)

Asymptomatic: Individuals who were HCWs were 169.2% (*P*<0.001, OR 2.692, CI=1.627-4.455) more like to be asymptomatic than "mild to moderate" in comparison to those who were not.

Severe: No significant relationship was established between being a "healthcare worker" and COVID-19 severity for this group.

Critical: Individuals who were HCWs were 34.8% (*P*<0.001, OR 0.652, CI=0.547-0.778) less likely than those who were not to have a critical than "mild to moderate" clinical outcome.

CLINICAL SYMPTOMS

As COVID-19 severity level classification for those who were asymptomatic was based on the absence of any COVID-19 clinical symptoms, therefore, data also showed no significant relationship for this group. For a better understanding, this section is divided based on the clinical outcomes of COVID-19, and a summary of the result between COVID-19 clinical symptoms and COVID-19 severity is provided.

Severe COVID-19 Severity

All COVID-19 clinical symptoms were found to have a significant relationship (both negative and positive) when clinical outcomes severe and "mild to moderate" were compared. Individuals who had fever (*P*<0.001, OR 1.176), subjective fever (*P*<0.001, OR 1.129), chills (*P*<0.001, OR 1.340), muscle aches (*P*<0.001, OR 1.251), cough (*P*<0.001, OR 2.024), sore throat (*P*<0.001OR 1.139), diarrhea (*P*<0.001, OR 1.241), nausea or vomiting (*P*<0.001, OR 1.441), and abdominal pain (*P*<0.001, OR 1.468) were 17.6%, 12.9%, 34.0%, 25.1%, 102.4%, 13.9%, 24.1%, 44.1%, and 46.8% respectively, more likely than those without these symptoms to have a severe than "mild to moderate" clinical outcome. However, headache and runny nose (rhinorrhea) were both to be 7.4% (*P*=0.001, OR 0.926) and 4.5% (*P*=0.031, OR 0.955) less likely to have a severe clinical outcome than "mild to moderate".

Critical COVID-19 Severity

All clinical symptoms of COVID-19 except for diarrhea were found to be significantly related to the clinical outcome “critical” than “mild to moderate”. Individuals who had muscle aches ($P<0.001$, OR 0.838), headache ($P<0.001$, OR 0.525), runny nose ($P<0.001$, OR 0.630), and sore throat ($P=0.012$, OR 0.871) showed a negative significant relationship.

They were 16.2%, 47.5%, 37.0%, and 12.9% respectively less likely to be critical than “mild to moderate.” Having fever ($P<0.001$, OR 2.013), subjective fever ($P=0.012$, OR 1.138), chills ($P<0.001$, OR 1.261), cough ($P<0.001$, OR 1.652), nausea or vomiting ($P<0.001$, OR 1.462), and abdominal pain ($P<0.001$, OR 1.534) were found to be 101.3%, 13.8%, 26.1%, 65.2%, 46.2%, and 53.4% respectively, more likely to be critical than “mild to moderate” clinical outcome.

Table 8: Multinomial Logistic Regression Output 1

	Asymptomatic			Severe			Critical		
Variables	OR	95% CI	*P-value*	OR	95% CI	*P-value*	OR	95% CI	*P-value*
Season of the Year (Ref: Summer)									
Winter	1.329	0.879 – 2.009	0.178	**0.921**	0.849 – 0.998	**0.045***	**0.246**	0.184 – 0.329	**<0.001****
Spring	**0.733**	0.578 – 0.930	**0.011***	**1.441**	1.360 – 1.528	**<0.001****	**2.100**	1.888 – 2.335	**<0.001****
Autumn/Fall	0.940	0.753 – 1.174	0.586	0.985	0.937 – 1.036	0.568	**0.592**	0.527 – 0.666	**<0.001****
US State Region (Ref: Mid-west)									
West	0.845	0.652 – 1.095	0.204	**1.294**	1.215 – 1.378	**<0.001****	**1.935**	1.731 – 2.164	**<0.001****
Sex (Ref: Female)									
Male	0.884	0.740 – 1.057	0.177	**0.953**	0.914 – 0.993	**0.023***	**1.406**	1.286 – 1.538	**<0.001****
Age group (Ref: Old Adults)									
Young Adults	**2.235**	1.709 – 2.923	**<0.001****	0.973	0.922 – 1.027	0.326	**0.185**	0.159 – 0.214	**<0.001****
Middle-aged Adults	**1.886**	1.493 – 2.382	**<0.001****	**0.874**	0.833 – 0.918	**<0.001****	**0.425**	0.384 – 0.470	**<0.001****
Race+ethnicity (Ref: White)									
American Indian/Alaska Native	2.057	0.243 – 17.449	0.508	0.614	0.361 – 1.043	0.071	2.192	0.954 – 5.040	0.065
Asian	0.978	0.363 – 2.636	0.964	**0.740**	0.611 – 0.896	**0.002****	1.157	0.764 – 1.752	0.492
Black	1.095	0.654 – 1.835	0.730	**1.221**	1.077 – 1.384	**0.002****	**2.169**	1.575 – 2.988	**<0.001****
Hispanic/Latino	1.387	0.759 – 2.534	0.288	**0.822**	0.721 – 0.936	**0.003****	1.273	0.917 – 1.768	0.149
Native Hawaiian/Other Pacific Islander	0.858	0.221 – 3.324	0.825	1.039	0.762 – 1.417	0.808	**1.934**	1.100 – 3.401	**0.022***
Multiple/Other	1.512	0.932 – 2.452	0.094	0.996	0.889 – 1.117	0.949	1.148	0.845 – 1.559	0.378
Healthcare Worker	**2.692**	1.627 – 4.455	**<0.001****	1.016	0.958 – 1.077	0.595	**0.652**	0.547 – 0.778	**<0.001****

**P*<0.05 **P<0.01

Table 9: Multinomial Logistic Regression Output 2

	Severe			Critical		
Variables	OR	95% CI	*P-value*	OR	95% CI	*P-value*
Fever >100.4F (38°C)	**1.176**	1.126 – 1.229	**<0.001****	**2.013**	1.830 – 2.215	**<0.001****
Subjective fever	**1.129**	1.078 – 1.182	**<0.001****	**1.138**	1.029 – 1.258	**0.012***
Chills	**1.340**	1.279 – 1.404	**<0.001****	**1.261**	1.137 – 1.397	**<0.001****
Muscle aches (Myalgia)	**1.251**	1.195 – 1.310	**<0.001****	**0.838**	0.759 – 0.925	**<0.001****
Headache	**0.926**	0.885 – 0.970	**0.001****	**0.525**	0.475 – 0.580	**<0.001****
Cough	**2.024**	1.928 – 2.125	**<0.001****	**1.652**	1.493 – 1.828	**<0.001****
Runny nose	**0.955**	0.915 – 0.996	**0.031***	**0.630**	0.566 – 0.701	**<0.001****
Sore throat	**1.139**	1.091 – 1.189	**<0.001****	**0.871**	0.783 – 0.970	**0.012***
Diarrhea	**1.241**	1.188 – 1.297	**<0.001****	1.079	0.977 – 1.192	0.132
Nausea or Vomiting	**1.441**	1.376 – 1.509	**<0.001****	**1.462**	1.315 – 1.625	**<0.001****
Abdominal pain	**1.468**	1.387 – 1.553	**<0.001****	**1.534**	1.351 – 1.742	**<0.001****

**P*<0.05 **P<0.01

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DISCUSSION

The purpose of this research was to investigate other risk factors that affect the severity of COVID-19 clinical outcomes within a specific subgroup (population with pre-existing medical conditions). The research objectives were designed to address various aspects which could potentially provide more insight into different COVID-19 severity within this subgroup.

To begin the study, a classification approach was developed to categorize the COVID-19 clinical outcomes based on severity levels. With this approach, a framework was provided for understanding the varying degrees of severity within the subgroup. Furthermore, the impact of the presence of pre-existing medical condition (PeMC) and its relationship to the clinical outcome severity of COVID-19 disease was explored. This objective aimed to confirm the relationship between PeMC and increased disease severity, which has been established in several research studies conducted on the COVID-19 disease (24,27,29,30).

Additionally, the study assessed the impact of sociodemographic factors such as sex, race and ethnicity, and age group, on the severity of COVID-19 disease amongst the population with PeMC. The aim was to identify the relationship, if any, between these factors and disease severity in this subgroup. The results aid in a better understanding of the disparities in outcomes within the individuals in this subgroup. Also, the study evaluated the impact of geographical location, to investigate whether certain regions were associated with a higher or lower disease severity within the study group of interest. The effect of the seasons of the year on COVID-19 severity was also explored, investigating whether certain times of the year were associated with different levels of disease severity. Furthermore, the study examined whether being a healthcare worker (HCW) had an impact on the severity of the COVID-19 disease in this subgroup. This objective aimed to understand if occupational exposure influences the severity of COVID-19 disease.

Finally, the relationship between COVID-19 clinical symptoms and the severity of the clinical outcome was evaluated to determine if specific symptoms were associated with increased severity within the subgroup. Th information shown from this analysis will serve as a foundation for proper management of the COVID-19 disease in individuals of this subgroup.

Overall, the study aimed to provide a comprehensive understanding of the risk factors associated with COVID-19 disease severity within the specific subgroup. The subsequent discussion will present findings with interpretations and likely implications, thereby contributing to the existing knowledge in epidemiological and COVID-19 research.

The study utilized the COVID-19 surveillance-restricted dataset provided by the Centre for Disease Control (CDC). It was important to exclude factors that could potentially influence the severity of the COVID-19 disease. Based on existing research, COVID-19 vaccination has been found to play a key role in the reduction of COVID-19 severity (39–41). As the study population is the US, it showed that COVID-19 vaccination began on the 11th of December 2020 (33). Therefore, the dataset used for the study was filtered to include only cases before the above-given timeline to examine the natural course of COVID-19 severity in the target population. Only laboratory-confirmed COVID-19 cases were also included in the study. Descriptive analysis and multinomial logistic regression (MLR) were conducted for the study. Descriptive analysis was used to have a comprehensive overview of the characteristic distribution of the variables of interest in the population. Logistic regression was used to measure the relationship between the predictor variables of interest and COVID-19 severity level. For the classification of disease severity, several research papers were used as a guideline in creating one. The study classified severity based on Asymptomatic, Mild to Moderate, Severe, and Critical. Hospitalization and death were not used for this classification, as these factors would have skewed the logistic regression. This is because, based on the classification system used, most individuals who were categorized as either severe or critical will have a higher tendency to have an outcome of being hospitalized or dying from the disease. Also, shortness of breath was excluded from the logistic for the same reason mentioned above.

A descriptive analysis of the study population of interest showed that the five most recorded COVID-19 clinical symptoms were cough, headache, muscle ache (myalgia), chills, and subjective fever. Within the study population, Females recorded a higher distribution frequency for COVID-19 clinical symptoms than males, while males had a higher occurrence of COVID-19 clinical complications, hospitalization, ICU admission, and death than females. Only one clinical symptom (shortness of breath) that had a bit higher prevalence amongst older male adults. Additionally, COVID-19 clinical symptoms were more prevalent among middle-aged adults than young and older adults, while clinical complications, hospitalization, ICU admission, & death were higher in older adults.

Seventeen (17) predictors were analyzed in this study. These spanned across socio-demographic factors (sex, age group, and race_ethnicity), geographical data (US State regions), seasonality (seasons of the year), occupational factor (healthcare workers), and COVID-19 clinical symptoms (fever, subjective fever, chills, muscle ache, headache, cough, runny nose, sore throat, diarrhea, nausea/vomiting, and abdominal pain).

In general, all seventeen predictors were significantly associated with the severity level of COVID-19. They were predictors which showed a positive relationship, and those which had a negative relationship. In the following paragraph, these relationships are discussed in detail.

SOCIO-DEMOGRAPHIC FACTORS

The study showed that the impact of sex on the severity of COVID-19 was found to exhibit divergent effects. When examining the outcome of "severe" disease severity, males demonstrated a lower likelihood (OR 0.953) of experiencing severe symptoms compared to those classified as having mild to moderate. Conversely, for critical severity, males demonstrated an increased likelihood (OR 1.406) of experiencing critical complications compared to the "mild to moderate" category. These observations highlight the nuanced relationship between sex and COVID-19 severity outcomes within the studied population. Several epidemiological research studies showed a similar relationship for the critical clinical outcome of COVID-19 for males (27,42–50). One of the explanations for the difference in clinical outcomes based on sex has been associated with the expression of membrane-bound angiotensin converting-enzyme 2 which plays a role in COVID-19 severity (45,47,48,51). Additionally, testosterone in males has been suggested to make men more predisposed to COVID-19 infection when compared to estrogen in females. The X chromosome and hormones have also been known to provide a protective role in innate and adaptive immunity (52). Also, as various research papers combined both the severe and critical severity classification, this might have played a role in distinguishing the specific relationship between sex and severity level (severe and critical). Several studies have reported that females had a more responsible attitude towards the COVID-19 pandemic than males (47,53) as well as higher rates of smoking and alcohol use (47). Existing evidence suggests that males tend to have a delayed healthcare-seeking behavior compared to females when feeling unwell. Subsequently, this delay in seeking medical attention often results in individuals presenting to healthcare providers or hospitals at more advanced stages of disease progression, characterized by increased severity or criticality. This pattern highlights additionally a sex-related discrepancy in the utilization of healthcare services, which potentially could lead to proper timely management and outcomes of various health conditions (54–56). Males also recorded a higher occurrence of clinical complications than females, this most likely influenced the direction of the relationship noted.

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In terms of age and age group classification used in the study, young adults (18-39yrs) and middle-aged adults (40-59yrs) were found to be significantly more likely (OR 2.235, 1.886) to be asymptomatic than mild to moderate severity when compared to older adults (≥60yrs). Studies have reported highest proportions of asymptomatic COVID-19 infection in children and young people and lower in older adults (57–59).

These studies align with the findings of this research for COVID-19 severity level “asymptomatic” and age. Studies have also shown a relationship between the immune response system, COVID-19 severity, and age (60–62).

Asymptomatic COVID-19 outcome has been recorded in several studies, as this is a matter of concern for the public from a public health aspect (63). Being asymptomatic from an infection prevents the affected persons from taking extra precautions to avoid the transfer of infection. Asymptomatic individuals go about their day, without knowledge that they have an infection that they are currently spreading to the public, as asymptomatic does not mean non-transmittable. In comparison to severe and critical disease severity, middle-aged adults were significantly less likely (OR 0.879) to be severe, while both young adults and middle-aged adults were significantly less likely (OR 0.185, 0.425) to be critical than mild to moderate. From general knowledge, old age has been known to affect disease severity, as at this point in life, individuals are more prone to diseases as their immune system has started to degenerate. Therefore, this study aligns with other research studies conducted on COVID-19 severity about its criticality (27,45,47–49).

Race_Ethnicity showed different effects on the severity of COVID-19. Hispanics/Latinos and Asians were less likely (OR 0.740, 0.822) to be severe, while Blacks had a higher likelihood (OR 1.221) when compared to Whites. For critical disease severity, Blacks and Native Hawaiian/other Pacific Islanders were noted to be more likely (OR 2.169, 1.934) to have a critical clinical outcome than Whites. In general, the topic of health disparity amongst people of different race/ethnicity is still prevalent and relevant even in this 21st century. The topic of health disparity has been an area of interest in the public health sector. Outcomes from these studies will aid in a better understanding of the necessary policy actions to bridge the gap between individuals of different race/ethnicity. This study agrees with other research studies on the relationship of race/ethnicity on disease severity. Blacks/African Americans, and minority ethnic groups are on the extreme when it relates to the criticality of the COVID-19 disease (49,64,65).

This study differs in terms of the protective factor found for Asians and Hispanics/Latinos, although minority groups, they do not align with some research studies carried out thus far (65). These differences amongst minority ethnic groups versus Caucasians might be based on other factors such as healthcare accessibility, distrust in the healthcare system, or a higher prevalence of the disease.

GEOGRAPHICAL LOCATION

Cases recorded in the West (West and South) were more likely to be severe and critical (OR 1.294, 1.935) rather than "mild to moderate" clinical outcomes than cases from the Mid-west (Midwest and Northeast). The CDC stated that the disparity between geographical locations might likely have been contributed by the different approaches and availability taken on Sars-Cov-2 testing and differences in the timing of introduction and early transmission of Sars-Cov-2 (66,67). Additionally, geographical differences might also be based on the inhabitants of these regions. Do these regions consist more of males, older adults, or minority groups that have already been noted to have a worse outcome based on this study.

SEASONS OF THE YEAR

The study showed that COVID-19 cases of those who were asymptomatic were less likely (OR 0.733) to have been during the spring season when compared to cases in the summer season. However, the spring season increased the likelihood of being more severe (OR 1.441) and critical (OR 2.100). This can be interpreted that the spring season was significantly related to increased disease severity when compared to the summer season. During the winter season, the data showed that COVID-19 cases were less likely to be neither severe (OR 0.921) nor critical (OR 0.246) in comparison to the summer season. This shows that during the winter season, there was a decrease in disease severity. Autumn/Fall season only showed a significant relation for critical COVID-19 severity, and it was less like (OR 0.592) for cases to be critical rather than mild to moderate. The outcome of the autumn/fall season shows more "mild to moderate" cases during this season than during the summer. Both winter and autumn/fall seasons were negatively related to COVID-19 severity, which shows a decreasing effect of severity, while the spring season had an increasing effect on disease severity. Several research studies have shown similar effects when compared to this study.

They show that mortality was stronger during the colder climates and COVID-19 seasonality was more pronounced at higher altitudes (68). However, these research studies do not completely align with this study, as the cold season comprises different seasons, and can have varying effects on COVID-19 severity. This is where this study plays a key role, as the relationship between the different cold seasons of the year was studied and analyzed. The study has been able to specifically point out that the spring season plays a role in the ascending increase of disease severity for COVID-19.

OCCUPATIONAL FACTOR

The COVID-19 outbreak led to a halt in people's lives both professionally and privately. Almost all professional sectors experienced a lockdown during this time in 2020. However, there was a particular sector that needed to still be functional, and this was the healthcare sector. In this study, the relationship between healthcare professionals and the disease severity of COVID-19 was investigated, as this will provide a perspective that most research studies have not evaluated. Based on this study and population studied, individuals who were HCWs were more likely (OR 2.692) to be asymptomatic, and less likely (OR 0.652) to be critical than mild to moderate. A study that analyzed COVID-19 in HCWs across studies from various countries also found the same outcome for critical severity. HCWs were found to be less likely to be severe or critical than in all COVID-19 positive patients (69). The high likelihood of healthcare workers being more asymptomatic may have stemmed from the fact they consisted more of young and middle-aged adults than older adults.

As discussed above being asymptomatic have being noted more in children and younger adults than older adults, this might be one factor that affected HCWs having a higher tendency to be asymptomatic than mild to moderate. It can also be due to the exposure of nosocomial infections which they are highly exposed to, which helps build up their immune system. The immune system build-up might additionally explain their likelihood to be asymptomatic than mild to moderate. In terms of criticality for HCWs which was found to be less likely in comparison to non-healthcare workers, this might be explained by the fact that HCWs have a better knowledge of their body system and disease process. This knowledge provides them the opportunity to seek medical care as soon as possible, providing them a huge advantage over those in the non-health sector.

Additionally, easy accessibility to the healthcare system also facilitates the help-seeking behavior of HCWs (69). One research paper (58) was found to have the same outcome for HCW being more asymptomatic when compared to the rest of the COVID-19 cases.

CLINICAL SYMPTOMS

Throughout the various research studies conducted on the topic of COVID-19, clinical symptoms have been highly studied, as these have aided in better management of the COVID-19 disease. cough, headache, muscle pain, chills, and subjective fever were the top five most prevalent clinical symptoms found in the PeMC subpopulation.

The study showed that presented with the following symptoms (fever [OR 1.176], subjective fever [OR 1.129], chills [OR 1.340], muscle ache [OR 1.251], cough [OR 2.024], sore throat [OR 1.139], diarrhea [OR 1.241], nausea/vomiting [OR 1.441], and abdominal pain [OR 1.468]) were found more likely be severe than mild to moderate. The clinical symptom "cough" had shown the highest likelihood among the above-mentioned symptoms. However, individuals who had a headache (OR 0.926) and runny nose (OR 0.955) were found to be more likely to be mild to moderate than severe.

For critical disease severity, the following clinical symptoms showed a higher likelihood in critical cases than mild to moderate. These symptoms were (fever [OR 2.013], subjective fever [OR 1.138], chills [OR 1.261], cough [OR [OR 1.652], nausea/vomiting [OR 1.462], and abdominal pain [OR 1.534]). Conversely, muscle aches (OR 0.838), headache (OR 0.525), runny nose (OR 0.630), and sore throat (OR 0.871) had an opposing effect on severity. Individuals with these symptoms were less likely to be of critical disease severity. Headache and runny nose had a consistent relationship (protective factor) with both severe and critical disease severity from this study.

In comparison with the research studies that have been conducted, different clinical symptoms have been found relating to COVID-19 severity. The following clinical symptoms have been found to be related to COVID-19 severity: cough, dyspnea (24), fever (37,70,71), nausea (72), and abdominal pain (24). Several research studies have shown that the clinical symptoms of COVID-19 infection can be complicated and non-specific. Nevertheless, the information provided through these studies has helped guide public health decisions and policymaking during the pandemic.

STRENGTHS AND LIMITATIONS

The major strength of this research study is being a quantitative study, in that study can be replicated by other researchers/peers to confirm or challenge the findings recorded above. Also, the large sample size used in this study enhanced the statistical power analysis, which allowed for a more accurate estimate of the relationship and generalization to the study population. Additionally, appropriate study designs were used to analyze and answer the research questions for this study. Lastly, the distribution of variables such as sex, and age group were distributed quite fairly in the dataset used.

They were as well some limitations recorded during this study, particularly related to the dataset used for study analysis. Firstly, as the COVID-19 case surveillance system is a passive, there was an underdiagnosing and underreporting of the true number of COVID-19 cases recorded in general during this period in the United States. As the sharing of public health data by the jurisdiction voluntary, reporting of COVID-19 varied by state and state-specific database systems. Secondly, as seen that the "pre-existing medical condition" variable included both underlying medical conditions (UMCs) and risk behaviors (RBs), which might pose different levels and degrees of relationship to disease severity.

The unavailability of data with UMCs/RBs listed respectively might have provided a different perspective on this study. However, the CDC confirmed that all UMCs/RBs have been established to be related to COVID-19 disease severity (73).

Thirdly, hospitalization, ICU admission, and death might be incomplete during the time that dataset was extracted, as the status was "unknown" during reporting. This might not be the case for this study, as the data used for the research study was two years back. It might also be that the data elements do not represent the current outcomes due to changes in outcomes that were not updated in the case report form. There might have also been errors during the data entry process.

As this study focused on cases before the availability of COVID-19 vaccination publicly, if there were individuals who participated in clinical trials for the development of COVID-19 vaccination, this would have influenced this study. Lastly, they were US states which were more represented than the others in particular US regions, therefore data might have provided a one-sided insight into the relationship with COVID-19 severity based on geographical location.

CONCLUSION

This study was able to discover risk factors that were found to be related to COVID-19 disease severity amongst the adult population with PeMC in the United States. Being asymptomatic can be a silent killer, as this does not protect one from having the disease progress to a more complicated state, and by then, this might be late. This study discovered a higher death rate amongst this group than for severe cases, showing the utmost concern for this issue.

Seasonality data was able to detect specific seasons of the year that had worse disease outcomes. The spring season showed a high and steady likelihood throughout the severity levels. The winter and autumn/fall seasons showed a protective effect against severity where the relationship was established. Geographically, the western region of the US showed a steady projection of likelihood from severe to critical disease severity than the mid-western region.

Regarding demographic factors, sex showed a nuanced relationship, while age group, showed that being a young or middle-aged adult is a protective factor across COVID-19 disease severity. Subsequently, belonging to a minority group in terms of race and ethnicity did not proffer the same relationship for all races/ethnicities. However, being Black/African American was consistent in having a bad outcome for COVID-19.

Being a healthcare worker provided a protective effect against COVID-19 disease severity. In terms of symptoms, "cough" was the symptom that had higher odds for severe disease severity, while it was "fever" for critical disease severity. Headache and runny nose were recorded to have had a protective effect on disease progression. Specific symptoms were found to be consistent with the direction of their relationship against disease severity, and these were: fever, subjective fever, chills, cough, nausea/vomiting, and abdominal pain.

The study was able to streamline three major factors contributing to COVID-19 severity, these are being male, older adults, and race_ethnicity. Males were at a higher risk for COVID-19 and being linked to having a high occurrence of disease progression to clinical complication, this further confirms the laid-back approach to seeking medical help for males. Therefore, it is important to educate men that seeking for help should not be seen as less manly and to continue encouraging them to seek medical help once something seems off in their body. Additionally, better preparation for aging for the elderly should be of utmost importance, as they become vulnerable during this stage of life. Lastly, fair treatment of all to bridge the gap between populations of different races and ethnic groups regarding disease susceptibility and progression.

Several factors like sociodemographic, immunological, genetic, and environmental factors contribute to the disease progression and severity of COVID-19. Therefore, none is more important than the other, as neglecting one creates a loophole from which issues can arise. Based on the risk factors discovered from this study, several recommendations can be provided to policymakers, to contribute to the fight and preparedness against emerging infectious diseases.

RECOMMENDATIONS

The study has been able to point out some major factors that can help to prepare the world at large, but especially the public health sector for emerging infectious diseases. The three major factors presented in this study were being male, an older adult, and being from a minority racial group. Several points can be introduced into the communities to help proffer solutions to the management of infectious diseases. These include:

- Health Education: Educating and encouraging individuals, both men, and women, to be in tune with their body, to know when something is not quite right, but also to take active steps by seeking medical help as soon as possible.
- Geriatric Preparedness: Aging cannot be stopped, but can be managed, to be able to have a good quality of life even at old age. As one age, their immune system becomes weaker, thereby becoming susceptible to diseases and infections. Therefore, it is apparent that we prepare for this stage of life by providing easy access to healthcare services (location and distance wise) and having live-in carers, so as not to be left alone.
- Health Equity: Minority groups have been found to most times have the worst disease outcome when compared to Caucasians “White”. These can be attributed to access to healthcare services, trust in the healthcare system to receive the best care possible, and to receive fair treatment irrespective of who they are. Fight against racism should be taken seriously, as this continues to be a public health concern.

In summary, the study underscores the importance of understanding and addressing the identified risk factors to mitigate COVID-19 disease severity. These findings contribute to the body of knowledge in epidemiology and offer valuable insights to healthcare providers, policymakers, and public health initiatives. By creating and implementing targeted interventions, and promoting inclusive healthcare practices, the journey of proper management and impact of emerging infectious diseases can be achieved.

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DECLARATION OF INDEPENDENT WORK

I hereby declare that I wrote this thesis without any assistance and used only the aids listed. Any material taken from other works, either as a quote or idea have been indicated under 'Bibliography'.

Place, Date

Signature

Submitted by: *Ifeoma Constance Udegbunam*
Matriculation number: [redacted]

APPENDIX

COVID-19 Case Report Form

CDC 2019-nCoV ID: ☐

……………PATIENT IDENTIFIER INFORMATION IS NOT TRANSMITTED TO CDC……………………

Patient first name ______________ Patient last name _________________ Date of birth (MM/DD/YYYY): ____/____/______

……………PATIENT IDENTIFIER INFORMATION IS NOT TRANSMITTED TO CDC……………………

Human Infection with 2019 Novel Coronavirus Case Report Form

Reporting Jurisdiction		Case state/local ID	
Reporting Health Department		CDC 2019-nCoV ID	
Contact ID[a]		NNDSS loc. rec. ID/Case ID[b]	

[a]Only complete if case-patient is a known contact of prior source case-patient. Assign Contact ID using CDC 2019-nCoV ID and sequential contact ID, e.g., Confirmed case CA102034567 has contacts CA102034567 -01 and CA102034567 -02. [b]For NNDSS reporters, use GenV2 or NETSS patient identifier.

Interviewer Information

Name of Interviewer: Last: First: Telephone: Email:

Affiliation/Organization:

Case Classification and Identification

What is the current status of this person?

☐ Lab-confirmed case* ☐ Probable case

If probable, select reason for case classification:

☐ Meets clinical criteria AND epidemiologic evidence with no confirmatory lab testing*

☐ Meets presumptive lab evidence‡ AND either clinical criteria OR epidemiologic evidence

☐ Meets vital records criteria with no confirmatory lab testing

*Detection of SARS-CoV-2 RNA in a clinical specimen using a molecular amplification detection test

‡ Detection of specific antigen in a clinical specimen, OR detection of specific antibody in serum, plasma, or whole blood indicative of a new or recent infection

Under what process was the case first identified? (check all that apply)

☐ Clinical evaluation ☐ Routine surveillance

☐ Contact tracing of case patient ☐ Other, specify: _________

☐ EpiX notification of travelers. If yes, DGMQID: ______________

☐ Unknown

Report date of case to CDC (MM/DD/YYYY):

___/____/______

Date of first positive specimen collection (MM/DD/YYYY):

___/____/______ ☐ Unknown ☐ N/A

Hospitalization, ICU, and Death Information

Was the patient hospitalized?

☐ Yes ☐ No ☐ Unknown

If yes, admission date 1 ___/___/_____ (MM/DD/YYYY) discharge date 1 ___/___/______

If hospitalized, was a translator required?

☐ Yes ☐ No ☐ Unknown

If yes, specify which language: ____________________

Was the patient admitted to an intensive care unit (ICU)?

☐ Yes ☐ No ☐ Unknown

If yes, admission date 1 ___/___/_____ (MM/DD/YYYY) discharge date 1 ___/___/______

Did the patient die as a result of this illness?

☐ Yes ☐ No ☐ Unknown If yes, date of death (MM/DD/YYYY): ____/____/_____ ☐ Unknown date

Case Demographics

Date of birth (MM/DD/YYYY): ____/____/______

Age: ______ Age units (yr/mo/day): ______

State of residence: ____ County of residence: ______

Does this case have any tribal affiliation? ☐ yes

Tribe name(s): __________ Enrolled member? ☐ yes

Sex:

☐ Male ☐ Other

☐ Female ☐ Unknown

If female, currently pregnant?

☐ Yes ☐ No ☐ Unknown

Ethnicity:

☐ Hispanic/Latino

☐ Non-Hispanic/Latino

☐ Unknown

Race (check all that apply):

☐ Black ☐ White ☐ Asian

☐ American Indian/Alaska Native

☐ Native Hawaiian/Other Pacific Islander

☐ Unknown ☐ Other, specify: __________

Which would best describe where the patient was staying at the time of illness onset?

☐ House/single family home ☐ Hotel/motel ☐ Nursing home/assisted living facility ☐ Rehabilitation facility ☐ Mobile home

☐ Apartment ☐ Long term care facility ☐ Acute care inpatient facility ☐ Correctional facility ☐ Group home

☐ Homeless shelter ☐ Outside, in a car, or other location not meant for human habitation ☐ Other (specify): ___________ ☐ Unknown

Healthcare Worker Information

Is the patient a health care worker in the United States? ☐ Yes ☐ No ☐ Unknown

If yes, what is their occupation (type of job)?

☐ Physician ☐ Respiratory therapist ☐ Other, specify: _________

☐ Nurse ☐ Environmental services ☐ Unknown

If yes, what is their job setting?

☐ Hospital ☐ Rehabilitation facility ☐ Other, specify:______

☐ Long-term care facility ☐ Nursing home/assisted living facility ☐ Unknown

Exposure Information

In the 14 days prior to illness onset, did the patient have any of the following exposures (check all that apply):

☐ Domestic travel (outside state of normal residence). Specify state(s): ____________

☐ International travel. Specify country(s): ____________________

☐ Cruise ship or vessel travel as passenger or crew member. Specify name of ship: ____

☐ Workplace

If yes, is the workplace critical infrastructure (e.g., healthcare setting, grocery store)?

☐ Yes, specify workplace setting: ________________ ☐ No ☐ Unknown

☐ Airport/airplane

☐ Adult congregate living facility (nursing, assisted living, or long-term care facility)

☐ School/university/childcare center

☐ Correctional facility

☐ Community event/mass gathering

☐ Animal with confirmed or suspected COVID-19. Specify animal: ________________

☐ Other exposures, specify: _________________

☐ Unknown exposures in the 14 days prior to illness onset

☐ Contact with a known COVID-19 case (probable or confirmed)

If the patient had contact with a known COVID-19 case:

What type of contact?

☐ Household contact

☐ Community-associated contact

☐ Healthcare-associated contact (patient, visitor, or healthcare worker)

Was this person a U.S. case?

☐ Yes, nCoV ID(s) ____________, ____________, ____________

☐ No, this person was an international case and contact occurred abroad

☐ Unknown if U.S. or international case

Is this case part of an outbreak?

☐ Yes, specify outbreak name: ____________ ☐ No ☐ Unknown

Submitted by: *Ifeoma Constance Udegbunam*

Matriculation number: [redacted]

CDC 2019-nCoV ID: ______

……………PATIENT IDENTIFIER INFORMATION IS NOT TRANSMITTED TO CDC……………………

Patient first name ______________ Patient last name ________________ Date of birth (MM/DD/YYYY): ____/____/______

……………PATIENT IDENTIFIER INFORMATION IS NOT TRANSMITTED TO CDC……………………

Human Infection with 2019 Novel Coronavirus Case Report Form

Clinical course, symptoms, past medical history, and social history

Collected from (check all that apply): ☐ Patient interview ☐ Medical record review

Symptoms present during course of illness:

☐ Symptomatic
☐ Asymptomatic
☐ Unknown

If case was symptomatic:

What was the onset date?
Onset date (MM/DD/YYYY): __/__/____
☐ Unknown symptom onset date

Did the patient's symptoms resolve?
Date of symptom resolution (MM/DD/YYYY): __/__/____
☐ No, still symptomatic
☐ Symptoms resolved, unknown date
☐ Unknown if symptoms resolved

Did the patient develop pneumonia?
☐ Yes ☐ No ☐ Unknown

Did the patient have acute respiratory distress syndrome?
☐ Yes ☐ No ☐ Unknown

Did the patient have an abnormal chest X-ray?
☐ Yes ☐ No ☐ Unknown ☐ N/A, no chest X-ray done

Did the patient have another diagnosis/etiology for their illness?
☐ Yes ☐ No ☐ Unknown

Did the patient have an abnormal EKG?
☐ Yes ☐ No ☐ Unknown ☐ N/A, no EKG done

Did the patient receive mechanical ventilation (MV)/intubation?
☐ Yes ☐ No ☐ Unknown
If yes, total days with MV (days) ____________

Did the patient receive ECMO?
☐ Yes ☐ No ☐ Unknown

If symptomatic, which of the following did the patient experience during their illness?							
Fever >100.4F (38C)[c]	☐Yes	☐No	☐Unk	Cough (new onset or worsening of chronic cough)	☐Yes	☐No	☐Unk
Subjective fever (felt feverish)	☐Yes	☐No	☐Unk	Wheezing	☐Yes	☐No	☐Unk
Chills	☐Yes	☐No	☐Unk	Shortness of breath (dyspnea)	☐Yes	☐No	☐Unk
Rigors	☐Yes	☐No	☐Unk	Difficulty breathing	☐Yes	☐No	☐Unk
Muscle aches (myalgia)	☐Yes	☐No	☐Unk	Chest pain	☐Yes	☐No	☐Unk
Runny nose (rhinorrhea)	☐Yes	☐No	☐Unk	Nausea or vomiting	☐Yes	☐No	☐Unk
Sore throat	☐Yes	☐No	☐Unk	Abdominal pain	☐Yes	☐No	☐Unk
New olfactory and taste disorder(s)	☐Yes	☐No	☐Unk	Diarrhea (≥3 loose stools/24hr period)	☐Yes	☐No	☐Unk
Headache	☐Yes	☐No	☐Unk	Other, specify: __________, ____________,	☐Yes	☐No	☐Unk
Fatigue	☐Yes	☐No	☐Unk	________________________________			

Did they have any underlying medical conditions and/or risk behaviors? ☐Yes ☐No ☐ Unknown							
Diabetes Mellitus	☐Yes	☐No	☐Unk	Immunosuppressive condition	☐Yes	☐No	☐Unk
Hypertension	☐Yes	☐No	☐Unk	Autoimmune condition	☐Yes	☐No	☐Unk
Severe obesity (BMI ≥40)	☐Yes	☐No	☐Unk	Current smoker	☐Yes	☐No	☐Unk
Cardiovascular disease	☐Yes	☐No	☐Unk	Former smoker	☐Yes	☐No	☐Unk
Chronic Renal disease	☐Yes	☐No	☐Unk	Substance abuse or misuse	☐Yes	☐No	☐Unk
Chronic Liver disease	☐Yes	☐No	☐Unk	Disability (neurologic, neurodevelopmental, intellectual, physical, vision or hearing impairment) If yes, specify: ______________________	☐Yes	☐No	☐Unk
Chronic Lung disease (asthma/emphysema/COPD)	☐Yes	☐No	☐Unk				
Other chronic diseases If yes, specify: ______________	☐Yes	☐No	☐Unk				
Other underlying condition or risk behavior, specify: ____________	☐Yes	☐No	☐Unk	Psychological/psychiatric condition If yes, specify: ______________________	☐Yes	☐No	☐Unk

SARS-CoV-2 Testing (approved by FDA or other designated authority)

Test	Pos	Neg	Indet./Inconc.	Pend.	Not Done
Molecular amplification test (RT PCR)	☐	☐	☐	☐	☐
Serologic test	☐	☐	☐	☐	☐
Other (specify): ______________	☐	☐	☐	☐	☐

Specimens for CoV-19 Testing

Specimen ID
1) ______________________
2) ______________________
3) ______________________

Additional Comments or Notes

Submitted by: *Ifeoma Constance Udegbunam*
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