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The impact and severity of non-covid-19 illnesses during covid-19 pandemic

Hanadi Alhammadi
haa7279@rit.edu

RIT

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By

Hanadi Alhammadi

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Student Name: Hanadi Alhammadi

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Capstone Committee:

Name	Designation	Date
Dr. Sanjay Modak	Chair of committee	

Name	Designation	Date
Dr. Ioannis Karamitsos	Member of committee	

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Abstract

The Covid-19 pandemic is a global crisis that occurred around the world and resulted in a large number of infections and deaths. As of September 2020, it was estimated that the Covid-19 pandemic had killed 976,000 people worldwide, healthcare facilities were burdened with containing this pandemic and made great efforts to treat and protect people, but in turn the focus on containing the pandemic led to many side effects, one of these effects is death from causes other than Covid-19. During the pandemic, people were afraid to visit hospitals to avoid contracting the COVID-19 virus, and hospitals were under great pressure due to the huge number of patients infected with virus COVID-19 which resulted in excessive deaths from causes other than Covid-19, in addition, some countries around the world suffer from delays in reporting it. In United States, between 2019 and 2022, the deaths rate increased in all ethnic disparities in all-cause mortality, the excessive death due to non-covid-19 was 20%. Also, in Brazil deaths from cardiovascular disease increased in less developed cities because of healthcare collapse. Many countries reported that the common reason for non-covid deaths was cardiovascular diseases and Stroke. In UK, deaths from non-covid-19 during 2020 increased by 10.9% compared with 2017.

Analysing the readiness and response of hospitals and their ability to provide the necessary health care during the pandemic period is important in order to measure their preparedness for future crises. The research purpose is to study the impact of the pandemic on the mortality rate of non-Covid-19 patients for the period from March 2020 to December 2020. In addition, this study aims to evaluate the effects of the pandemic on excess mortality of non-Covid19 patients and how policy makers can prevent this problem in the future. The results will help public health decision makers formulate policies and decisions aimed at community health and national stability. In addition, the results will show the impact of the pandemic on deaths in the UAE and its ability to manage crises. For this purpose, the data were obtained from the Emirates Healthcare Services (EHS) in UAE for this purpose. To analyse the data and find out the difference in non-Covid-19 deaths during the pandemic compared with last two years, Time series analysis method will be used in this research.

The analysis showed that the number of non-Covid-19 deaths increased significantly during the pandemic compared to the pre-pandemic period. Demographic factors such as age, sex, and nationality were important predictors of the likelihood of death. Patient admissions decreased significantly in all departments (inpatient, outpatient and accident and emergency) during the pandemic period. However, there was a negative association between the monthly number of non-Covid-19 deaths and the monthly number of outpatients and accident & emergency patients, but no significant relationship between the monthly number of non-Covid-19 deaths and the monthly number of inpatients.

Keywords: Non-Covid-19 mortality rate, T-test, Logistics Regression, Multiple Linear Regression, Excessive Deaths, Covid-19 Pandemic.

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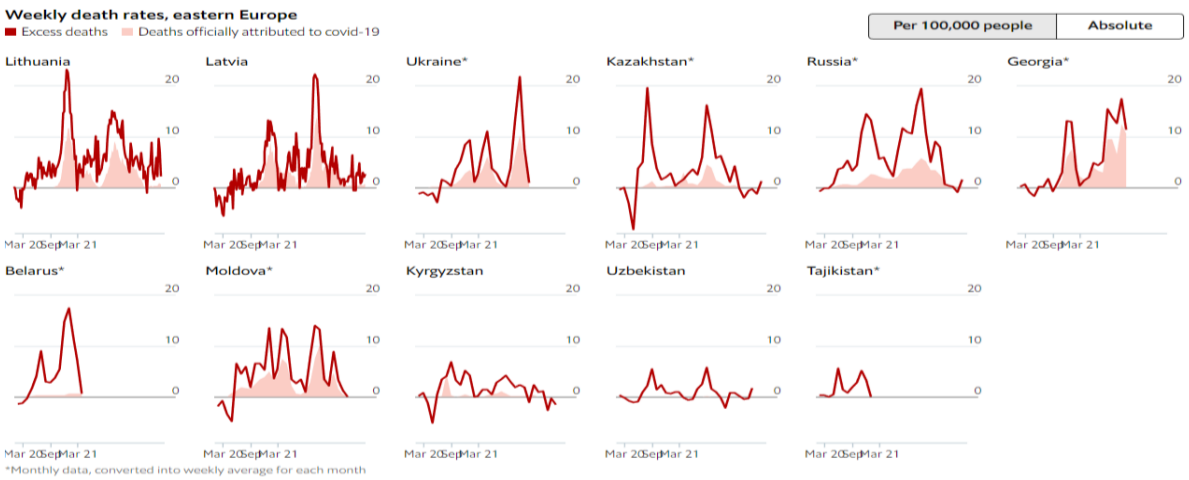
Chapter 1

1.1 Introduction

The novel coronavirus SARS-CoV2 is a global crisis that occurred all over the world, which resulted in a huge number of infections and death. The first cases of infection were discovered in Wuhan, China in December 2019. In September 2020, it was estimated that the Covid-19 pandemic had killed 976,000 people worldwide, the first case was announced in the United Arab Emirates in January 2020 of a Chinese woman, who was treated and released from the hospital, in March 2020 the first two deaths were announced, so National sterilization campaigns begun in order to protect the people from the infection. After that, in December 2020 Ministry of Heath started the vaccination campaigns. UAE announced the total number of people infected with Covid-19 till Oct 2022 is 1,012,646 and the number of deaths caused by covid-19 is 2,347. The pandemic has prompted governments across worldwide to take extraordinary and often untested steps aimed at slow or limit the spread of the disease, healthcare facilities were burdened with containing the pandemic and they made great efforts to treat and protect people by imposing some regulations to contain the pandemic such as hand hygiene, physical distance and the closure, in addition to that health care facilities priorities the care to be given for the covid-19 patients and suspended the outpatient clinics and non-urgent operations, but in turn, the focus on containing the epidemic has led to many side effects, one of which is putting patients with serious condition at risk which has led to excessive deaths from causes other than Covid-19. On the other hand, people were afraid to visit hospitals to avoid contracting the COVID-19 virus, and hospitals were under great pressure due to the huge number of patients infected with COVID-19 which resulted in excessive deaths from causes other than Covid-19 and in some countries around the world they suffer from delays in reporting it. In United States, between 2019 and 2022, the deaths rate increased in all ethnic disparities in all-cause mortality, the excessive death due to non-covid-19 was 20%. Also, in Brazil deaths from cardiovascular disease increased in less developed cities because of healthcare collapse. Many countries reported that the common reason for non-covid deaths was cardiovascular diseases and Stroke. In UK, deaths from non-covid-19 during 2020 increased by 10.9% compared with 2017. Figure (1) illustrate the excessive death in some countries.

The research purpose is to study the impact of the pandemic on the death rate for non-covid-19 patient for the period from March 2020 to December 2020 and compare it with the pre-pandemic baseline data for the same period from 2018 to 2019, in addition to that, this paper aims to assess the effects of the pandemic on the excessive deaths of non-covid19 and how the policy maker can prevent this problem in the future by maintaining stability in society and a balance between dealing with epidemics and people's health. The data obtained from the Emirates Healthcare Services (EHS) in UAE for this purpose.

The key finding from the analysis is that there was a significant increase in non-Covid-19 deaths during the pandemic period (March 2020 - December 2020) compared to the pre-pandemic period (January 2018 to February 2020). Additionally, demographic factors such as age, sex, and nationality were found to be important predictors of the likelihood of death and that males and non-citizens may be at a higher risk for death than their counterparts. Furthermore, there was a significant difference in the number of patient admissions for all three departments (inpatient, outpatient, and Accident & Emergency) during the pandemic period compared to the pre-pandemic period, with all p-values being less than 0.05. However, there was a significant negative association between the monthly number of non-Covid deaths and only the monthly number of Outpatient (OPD) and Accident & Emergency (AE) patients, while there was no significant relationship between the monthly number of Non-covid-19 deaths and the monthly number of Inpatients.



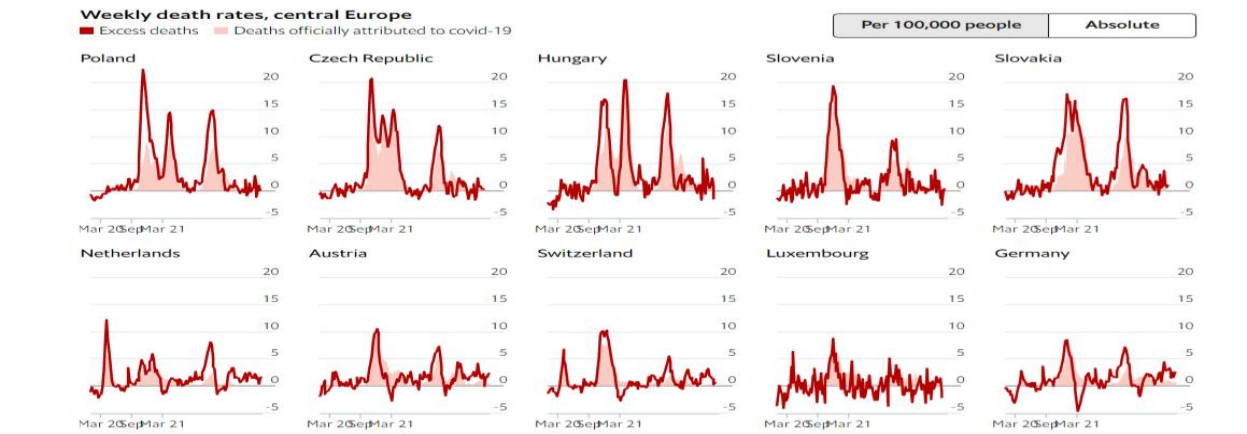


Figure 1. Weekly recorded COVID Deaths in most Countries around the world

Notes: The red line is the total deaths (Covid-19 and non-Covid-19) , the pink shading is Covid-19 deaths, the area in between the red line and the pink shade represents excess deaths per 100,000.

1.2 Statement of the problem

The Covid-19 pandemic is a global crisis that occurred across the world and left with it many direct and indirect effects, the direct results were the numbers of people infected with Covid-19 and the deaths resulting from it, while the indirect effects were the psychological effects, including fear of visiting healthcare facilities and non-coivd-19 deaths that result from it, many countries around the world have reported excessive deaths during the pandemic, some related to covid-19 and others not, raising the question whether non-Covid-19 deaths are exceeding the average death rate compared to previous year and whether these pandemic have been contained and has got its side effects under control. This motivates the interest of this research, and the problem that this research paper seeks to address concerns the effect of covid-19 pandemic on non-covid-19 deaths in the UAE.

1.3 Research Aim and Objectives

The aim of this study is to find the effect of Covid-19 on the non-Covid-19 deaths in the UAE, by comparing the non-Covid 19 death rate in 2018-2019 and 2020.

The objectives of this research are as follows:

1. To determine the rate of change and the relationship between number of deaths and patients visits to the hospital three departments (Inpatient, Outpatient, Accident and Emergency).
2. To find the association of participants' demographic factors or other potential predictors of non-Covid-19 deaths.

1.4 Research Methodology

For data mining and machine learning projects, the CRISP-DM (Cross-Industry Standard Process for Data Mining) methodology is frequently utilized. There are six steps in total: Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, and Deployment. Although they may be repeated, these stages are carried out in order. The approach offers a well-organized framework to guarantee that the project is concentrated on the business issue and that the findings are reliable and useful.

To achieve the aims and objectives of the study, this research study will employ statistical learning techniques to get adequate information regarding the questions of the study. This research will make use of the dataset owned by EHS to get a detailed understanding of the issues of concern regarding the topic in question.

Secondary research was employed through an intensive internet search on issues relative to the questions of the study hence making the findings of the study. In order to find answers to the questions of the study, this research will rely on desktop research as well as the use of the dataset. There are many modelling tools such as R, Python, Weka and SAS. In this research R programming language have been chosen to perform the analysis and perform this paper goals.

Upon collecting the necessary information successfully, the data collected shall be analysed effectively, and it will be presented through tables and graphs depicting the findings of the study. The findings of this study will also be explained in detail for an understanding of the people that

may find the findings of the study effective and helpful, as pointed out in the significance of the study.

Since the study includes retrospective data, collection of informed consent from the patients is not included in the current research. Ethical approval for the conduct of the research will be attained from REC committee of MoHAP and administrative approval from EHS. Wareed data will be used for the research and data security will be ensured as per the policies and procedures of EHS.

Data analysed using R programming language and Tableau. Descriptive and inferential techniques applied according to the nature of the variables. All normally distributed continuous variables summarized using mean±SD, if there were non-normal quantitative variables they can be presented with median, inter quartile range with minimum and maximum. Rate of change in the non-covid death will be calculated based on the data of 2018 to 2020. Significance in the rate of change will be identified using appropriate inferential technique.

Significant factors identified from the preliminary stage will be included in the logistic regression model to find the best determinant of non-covid-19 death. Among the patient characteristics with two groups, Proportion of non-covid death will be compared using t-test. If variables are non-normal, alternative non-parametric tests will be applied to achieve the study objective. Null hypothesis will be tested at 5% level of significance, decision on acceptance or rejection of the null hypothesis will be taken effectively based on 5% significance level.

1.5 Research Hypotheses

This research is premised on the hypothesis that given that Covid-19 Pandemic spread out across the world thus result in many side effects, one of which is non-covid-19 deaths, these excessive deaths increased the deaths rate of non-covid-19 deaths due to people's fear of visiting the hospitals to avoid contacting covid-19 patients, in addition to that healthcare facilities were burdened with containing the pandemic so they were forced to priorities the care to covid-19 patients, suspended outpatients clinics and non-urgent operations which might led to put patient with serious condition at risk. Therefore, the extent to which non-Covid-19 deaths are affected by the Covid-19 pandemic in the United Arab Emirates will be studied, and if there are excess deaths due to causes other than Covid-19.

H1 hypothesis- there is no significant difference in non-Covid-19 mortality rate between the first wave of the pandemic (Mar 2020- Dec2020) and (Jan 2018 to Feb 2020).

H2- hypothesis- participants' demographic features or other factors has no association with non-Covid-19 deaths.

H3- hypothesis- there is no significant difference in admission to the hospital departments between (Mar 2020- Dec2020) and (Jan 2018 to Dec 2020).

H4- hypothesis- hospital departments (Inpatient, Outpatient and Accident & Emergency) have no association with non-Covid-19 deaths.

The below table outlines the terms that will be frequently used and their respective definitions:

Table 1. Terms with their definitions

Term	Definition
Covid-19	An infectious disease caused by the SARS-CoV-2 virus occurred across the world caused severe acute respiratory syndrome coronavirus.
Pandemic	An outbreak of disease occurring worldwide and infecting many individuals at the same time.
Non-Covid-19 Deaths	Deaths occurred because of other reasons than covid-19 during the period of Covid-19 Pandemic.
Excessive Deaths	Deaths during a given period are higher than the number of deaths expected under normal conditions, which could show the effect of something like a disease or adverse event
Lockdown	It is an emergency situation in which people are not allowed to move freely because there is a danger that needs to be contained
Health care readiness	assess and monitor the extent of healthcare facilities services availability and readiness to support the planning and managing of a health system.
ICD-10 coding	stand for International Classification of Diseases, ninth/tenth revision used in medical field as acronyms for the disease, it promotes international comparability in the collecting, processing and classification of diseases and causes of deaths
Wareed	The electronic system used in Emirates Healthcare Services to collect the data of all activities in healthcare facilities.
Non-covid19 death rate per year	Number of deaths occurred due to other reasons than covid-19 / total deaths in the specific year

1.5 Significance of the study

This project aims to assess the impact of the pandemic on excess deaths among non-covid19 and to determine how policymakers in the UAE can prevent this problem in the future by maintaining stability in society and balancing between dealing with epidemics and people's health. This project will be of great interest and help decision makers understand the indirect effects of the Covid-19 pandemic, which lead to fear in society and associated mortality. The results will help public health decision makers formulating policies and decisions aimed at the health of the society and the stability in the country.

Chapter 2

2.1 Literature Review

The literature review conducted for this research highlights the potential indirect effects of the Covid-19 pandemic on non-Covid-19 deaths, including disruptions to healthcare services and changes in health-seeking behaviour. Previous studies have also explored the impact of pandemics on excess mortality and the need for strategies to mitigate their negative effects.

John Apple (2020) notes that in UK there may be consequences to trying to contain covid-19 which are the increase in deaths from other causes as well as the delay in reporting them, this is due to people's fear of contracting Covid-19 disease, or they don't want to disturb NHS while they are busy containing the pandemic. Indicative of this, the number of emergency attendances which decreased by 29% and admissions decreased by 23% from 2019 to 2020, Those who did not come to the hospital for treatment are still unknown what happened to them and whether they received service from a medical practitioner who postponed their death for several months, or whether hospitals delayed treatment of these cases due to the pandemic. John Appleby notes that in the week ending 17 April 2020,11854 more people died than the equivalent five-years average for this week, (8758) registered for covid-19 death while (3096) for other causes, furthermore, dealing with covid-19 might have a negative impact on other causes of death, particularly other respiratory causes. Also, John Appleby notes that there might be a problem with deaths data, there's a potential that there were undercounted covid-19 deaths and that's led to an artificial increase of non-covid deaths. The Office for National Statistics (ONS) figures supports this idea, from 13 March to 17 April total deaths increased from (11017) to (22351) by 103%, Covid-19 deaths accounted for 70% in hospitals, 23% home care, 7% in homes and other places, the low number of COVID-19 tests outside hospitals makes it possible that the number of people who have died outside of hospitals might be died because of COVID-19.

Bodilsen, J. et al. (2021) from Denmark notes that it's important to analyse the hospital response during the crisis to ensure that hospitals are ready to provide the necessary health care at the time

of the pandemic and to measure its readiness to future epidemics, governments across worldwide imposed some restrictions to contain the pandemic such as physical distance, hygienic precautions and the closure of governmental and private institution, also the health care sector priorities the care to be given for the covid-19 patients, they suspended the outpatients services and non-urgent operations, however this may put patients with serious and acute medical conditions other than COVID-19 at risk. The authors notes that in Denmark there were many phases of the pandemic between the lockdown and rolled back of restrictions in order to gradually back to normal life. The authors notes that the hospital admission rate before the pandemic was 204.1 per 100000/week, it decreased during the first lockdown by 30% (142.8 per 100000/ week) and by 22% (158.3 per 100000/ week) during the second lockdown, the admission rate for non-covid groups with other diseases (such as respiratory diseases, cancer, pneumonia, and sepsis) decline during the lockdown and even during the phases of gradual reopening, few restrictions, and regional lockdowns, the number of hospital visits for these groups remain low, however the deaths rate slightly increased for that's group compared with the pre-pandemic baseline period. The Authors compared other studies and noted that since the onset of the covid-19 pandemic there was a concern around the world from physician and researchers that patients will not seek for medical care when needed and the capacity of healthcare services which is overburdened will not be able to provide healthcare services with timely diagnoses and treatment. Furthermore, many hospitals in New York reported a decrease of more than 50% in overall hospital contacts across several major disease groups. The authors conclude in this article that the decrease of overall rate of hospital admission was expected due to the restriction imposed by the Danish government to ensure continuity of healthcare services provided during the first lockdown and it was gradually approached baseline levels for most major disease groups before the second national lockdown. In addition, lower rates persisted for some serious medical conditions such as respiratory diseases and cancer were observed for new patients not being diagnosed and for patients with known disease not treated at hospital or monitored by specialised outpatient follow-up. In general, they didn't observe an overall excess mortality on a population level in Denmark until the second national lockdown in December and the key reason for that was the greater severity of the second wave of covid-19 in Denmark and associated deaths.

Dey, S. and Davidson, J. (2021**),** note that the pandemic caused death all around the world nearly 976,000 people as of September 2020, many investigated in Covid-19 deaths, but few investigated

in non-covid deaths as some called it collateral damage of the pandemic, people delayed getting diagnosis and treatment in a timely manner, either because they avoided visiting healthcare facilities, or because these facilities were exhausted from dealing with the pandemic and postponed treatment of other conditions, they were in difficult situation that they must decide who receives life-saving treatment. Also, the authors note that the excess deaths from the pandemic exceed reported Covid deaths in every country and that the high numbers of non-COVID deaths are large enough to be seen as a pandemic of its own. The Authors note that the cancer treatment delayed in US and UK for cancer patients and there was lake of the resources needed for these cases such as doctor time, hospital beds and blood which can lead to death, also this was the case with cardiology patients, the cardiologist reported 40-60% reduction in heart attack admission due to the same reasons, fear of contracting with covid-19 patients which led to permanent damage or death, furthermore in Austria the number of heart attack deaths exceed Covid-19 deaths and in Spain there was a reduction in treatment for myocardial infarction (MI) and the number of these cases increased in Hong Kong, that was as result of some policies to contain the pandemic such as lockdown which caused a reduction in GDP in many countries such as UK which witness a decrease by 20.4% and India by 45%, thus can led to deprivation and economic anxiety and poor mental health. However, deaths caused by pollution, traffic and work accidents maybe pushed down due to the pandemic restriction. The Authors found in this research that there's a significant positive effect of covid on excess deaths and the stringency restrictions increased the excess deaths by up to 16 million per week. Also, they find that reductions in searches for medical conditions, particularly stroke, are consistently linked to higher excess deaths and that COVID deaths have the greatest result when excess deaths are high, and stringency when excess deaths are low.

Perkin, M.R. et al. (2020), they note that this research divided the participant (Black,Aisa and minority ethnic communities) into three groups which are group(1) COVID-19-associated deaths in the 6-week period, group (2) non-COVID deaths in the same period and group (3) all deaths in a comparison period of the same 6 weeks in 2019, their remark was that deaths increased in group (1) and (2) also, it was independent from the different variables (comorbidities, sex, age and deprivation) and they conclude that there was major risk factors for COVID-19 mortality including male sex, diabetes, having multiple comorbidities and background from the BAME communities,

in addition there’s a need to have a better understanding of the relationship between ethnicity and mortality during the pandemic and if there's a need to put more concern of these categories.

Barach, P. et al. (2020), they note that the spread of Coronavirus caused a global crisis which impacted the healthcare and economic in all over the world, it was the most infectious disease of the past 100 years, as a consequences of Covid-19 pandemic there was many serious illnesses and deaths not just from Covid-19 but it happened as a result of social disruption such as fear, lack of trust and structural dysfunction in accessing and paying for medical care. Also, they note that social upheavals such as stress, depression, anxiety and frustration double the risk of AMIs and strokes as the stress is connected to brain-heart disease, all these factors caused an increase in the number of patients with heart disease, strokes, and other acute diseases as they were afraid of contracting with covid patients and avoid getting the necessary medical care. Also, in their article they note that many countries have experienced a decrease in admission of myocardial infarctions (AMI), moreover, hospitals in Italy experienced a drop in admissions for AMI cases by 49% compared to the same period the previous year, also they experienced increase of AMI fatality in non-infected people with Covid-19 who do present to hospital as well, therefore the overall deaths from AMI increased by 75%. The Authors note that there was a reduction in hospitalizations for heart failure cases by 47% and 53% for atrial fibrillation and worse outcome for those who visit the hospital, also there was a cardiac complication of STEMI intervention which increased by 80%. The authors note that these findings are in line with studies reporting up to 50% declines in the number of STEMI interventions, AMI hospitalizations, and aortic dissections in the US, Hong Kong, and Spain during the pandemic. The crude mortality increased in some countries such as US, Italy and Sweden, but it decreased in others like Israel and Norway, however that’s raised questions about how public data are defined, collected and reported. Moreover, there has been a decrease in the number of vaccinations and preventive services, due to fear of contagion during the pandemic, the infectious disease immunization and monitoring programs has been disrupted, as the immunized population become smaller the contagious and deadly disease such as measles, polio, and pertussis may begin to proliferate which will lead to death in children and adults. In addition, essential medicines, including vaccines, has been reduced because of the disruption of supply chains, transportation problems, flight cancellations, trade restrictions among countries, and border closings.

Jacobson, S.H. and Jokela, J.A. (2020), note that in US the Pandemic resulted in more than 7 million people infected with covid-19 and more than 210000 deaths, So the government-imposed lockdown law which will help to control the consequences of the pandemic which is represented in reduce the spread out of the virus, reduce the demand of intensive care units beds and ventilators and gain time to provide healthcare workers with personal protective equipment, Enforcement of this law will help protect a group that appears to be at risk of contracting covid-19, such as those over the age of 65 and those with underlying health conditions, the authors note in their article that there was an increase in weekly non-coronavirus-related deaths compared to weekly deaths in 2019, during the pandemic there were delays in the provision of medical care resulting in excess deaths, according to the authors this maybe happened for two reasons, first, Weekly deaths for 2019 were not uniformly distributed throughout the year, which is highly likely, second explanation as the 2020 population is higher than in 2019, there may be more deaths, although this increase is likely to be very little compared to the actual number of deaths.The authors note that the main conclusion from this analysis is that excess deaths among different age groups and nationalities occurred beyond COVID-19 deaths and these excess deaths indicate that people across many age groups and genders died unexpectedly.

Ku, C.-C. (2021), notes that COVID-19 spread over the world and caused huge number of deaths, these mortality is a measure to assess the losses has caused by the pandemic, the author notes that excess mortality is determined by comparing the observed mortality to the expected mortality without COVID19, he mentions also, to obtain a high quality data there must be some rules, first, well established registration system. second, events that have an impact on the population such as regional conflicts and natural disasters that can have a significant impact on the population and need attention. Finally, A large outbreak of the disease at the beginning of the pandemic may lead to system failure and inability to examine and issue death certificates. The author notes that he compared the mortality in 2022 with the past five years using a time series model adjusted for seasonality. There are vulnerable groups in society at risk of Covid-19, and the division of deaths indicates the groups that were most affected by the pandemic, and this division helps to identify these groups that need protection. The author described the excess deaths, which were studied through some variables such as age, gender, and race, and it was found that these deaths were

found in a large proportion among the elderly and the non-white population, also he mentioned from other studies that socioeconomic status can affect the excess mortality such as income level and standard of living, in addition to the fact that there was higher excess mortality among older adults in nursing home compared to noninstitutionalized adults at a similar age. The author notes that patients with underlying conditions and diseases avoided visiting health facilities, which reduced the chance of timely diagnosis and treatment of the disease, which led to poor outcomes, including death. There was indirect impact on patients who have respiratory diseases and other diseases associated with mental health such ad suicide and mental illness which impacted excess deaths during the lockdown in some countries, however developed countries didn't experienced increase or decrease in suicide, this indicates that social safety nets and preventive measures have contributed to reducing the negative impact of the epidemic. However, there are fears that this rate will increase in the long term of the closure. Chu-Chang Ku notes that there was a variation in cause of deaths over time which reflect the societal and behavioural changes impacted by COVID-19, understanding these impacts will help to allocate the resources to tackle the challenges in each stage, furthermore the COVID-19 preventive measures such as wearing a face mask and social distancing can help reduce the spread of other infectious diseases and, conversely, can result in the health care systems being cut off from the people who need them, resulting in excess deaths.

Ben-Haim et al. (2021**),** note that the emergence of COVID-19 negatively affected the healthcare system due to the postponement of treatment time for patients who is not infected with COVID-19. The authors note that patients with heart conditions such as STEMIs and CVA (stroke) delay in arriving at healthcare institution due to Covid-19 concerns. The authors discuss in their paper the implications of the pandemic on non-covid 19 patients in emergency care settings. This study conducted for the period February 2020 to April 2020 and compare it to the same period in 2019 and they focus on three distinct diagnoses that need immediate intervention which are STEMI, CVA and hip fractures, in addition to observe mortality rate. The authors note that good arrangement, preparedness, and ability to manage the emergency department will certainly positively affect the quality of services provided to non-covid patients, it plays a crucial role in the healthcare system during the pandemic by isolating the covid-19 patients from non-Covid patients which will reduce the risk of disease transmission. The authors note in their study that patient

referrals decreased during the pandemic compared to previous year. Also, the mortality rate during the pandemic for non-covid patients was higher than those noted in the past 5 years.

Shiels et al. (2021), note that the goal of their study is to estimate excess deaths in the United States by racial/ethnic group, the source of these data is death certificate data from the Centres for Disease Control and Prevention (CDC) and population projections from the U.S. Census Bureau for March to December 2020. Despite the racial diversity in the United States, it is estimated that there were significant numbers of deaths that were directly and indirectly related to COVID-19. The excess deaths resulted in Covid-19 during 2020 was compared to prior year, the authors found that from March to Aug 2020, 20% of excess deaths was due to non-covid causes. The authors note that deaths from other illnesses not related to COVID-19 were two to four times higher per 100,000 population among blacks, American Indians/Alaska Natives, and Hispanics than among white Americans, the following diseases were the most common causes of death: diabetes, heart disease, and vascular disease, cerebrovascular disease, and Alzheimer's disease, this led to an increase in racial disparities in all-cause mortality, Although vaccination rates increased during 2021, but the disparity is continuing and will lead to a disparity in deaths in the different ethnic, attention must be drawn to this problem and try to solve it efficiently. Also, the authors note that 76% of the mortality rate was among people under the age of 45 and 22% for those over the age of 45, in addition to the fact that the disparity in the mortality in racial was clear, as the deaths were 9 times higher among black males compared to white males.

Brant et al. (2020), note that Brazil experienced excess mortality during the pandemic, so this study is conducted in particular to evaluate excess cardiovascular mortality during COVID-19 in 6 Brazilian capital cities. The Authors notice from the study that the number of cardiovascular deaths increased in most cities, especially the northern capitals, and most of them are closely related to home deaths, in addition the death rate in Brazil from cardiovascular diseases in less developed cities was greater than in developed cities due to the collapse of the health system. Moreover, in all cities, there was a noticeable increase in home deaths which is expected to be the result of misdiagnosis. In other studies, the authors found that in Northern Italy there was a significant decrease in hospital daily admissions due to acute coronary syndromes and 58% increase in out-of-hospital cardiac arrest which was strongly associated with cumulative COVID-19 incidence. In

addition, There was a decrease in cardiac catheterization laboratory activations due to ST myocardial infarction in the USA by 38% and in Spain by 40%, possibly due to avoidance of medical care for many reasons such as social distance, fear of contracting Covid-19 , misdiagnosis, scarcity of health care resources in some areas, as well as the collapse of health care system, and this will eventually lead to social disparities in the number of mortality.

According to a study conducted by Horita, N. and Fukumoto, T. (2022), death statistics provided by the Japanese Ministry of Health, Labour, and Welfare covering the period from January 2009 to March 2022 were analyzed to investigate the impact of the COVID-19 pandemic on respiratory deaths. The study found that there was a decrease in respiratory deaths during the pandemic era, which was defined as April 2020 and thereafter, compared to the pre-pandemic era. The study found that there was a significant decrease in monthly deaths from various respiratory infections, including pneumonia, seasonal influenza, pulmonary tuberculosis, acute bronchitis, invasive pneumococcal infections, chronic obstructive pulmonary disease (COPD), and bronchial asthma during the pandemic compared to the pre-pandemic period. However, deaths from respiratory malignancies, aspiration pneumonia, and interstitial pneumonia remained unchanged. The authors suggest that infection control measures aimed at preventing the spread of SARS-CoV-2 may have also contributed to the decrease in other respiratory infection-related deaths. It is recommended that appropriate infection control measures should continue even after the pandemic to suppress respiratory diseases.

Mulligan, C.B. and Arnott, R.D. (2022) highlighted how the COVID-19 pandemic has affected non-COVID health outcomes in the US. The patient and family efforts are emphasized as important contributors to preserving health in the human capital approach to health economics. A large portion of health is a "home production" activity. With the pandemic, many clinical preventive treatments and chronic illness management couldn't convert to telemedicine, and elective procedures like colonoscopies and lung cancer CT screens, among other procedures, that have prevented countless deaths through early diagnosis, were cancelled. Young adults aged 18 to 44 experienced a 26% increase in overall mortality during the pandemic, compared to older people (18%). It was not determined if public or private COVID policies were causing non-COVID health outcomes to worsen. Understanding the reasons for the additional fatalities is crucial because the

heightened mortality that started in the second quarter of 2020 has no obvious end. In addition to the 72,000 unmeasured COVID fatalities, the article projects 171,000 additional non-COVID deaths through the end of 2021.

Allison et al. -2021, in a study conducted in the United Kingdom, found that in a given area during the early pandemic (COVID-19) acute medical admissions and deaths from causes other than non-COVID were compared with a historical cohort from 2017. The findings revealed a marked decline in non-COVID hospital admissions during the pandemic, which was attributed to a lack of desire to seek medical care and higher referral criteria. Local non-COVID mortality did, however, only marginally increase during the pandemic, and the number of non-COVID deaths in Wales as a whole increased by barely 1% from the year before. The study hypothesizes that modifications in community lifestyle and behaviour during lockdown may have had unanticipated positive effects on health.

Mulligan, C. and Arnott, R. (2022), pointed out that the pandemic had caused considerable and historic health damages in the United States in addition to Covid-related mortality. Americans died from non-Covid causes at an average annual rate of 97,000 more than prior trends, with tens of thousands more young adults dying from drug-, homicide-, traffic-, and alcohol-related causes. Working-age individuals (18–64) experienced a 26 percent increase in all-cause mortality during the pandemic, compared to an 18 percent increase for the elderly. When compared to the monetary value of a statistical life used in government cost-benefit analyses, these excess deaths result in a loss of well over $1 trillion.

Mohamed, M.O. et al. (2020), The study examined pre-existing conditions in adult COVID-19 fatalities in England and Wales between March and May 2020, stratified by sex and age group, and compared it to fatalities not caused by COVID. The most prevalent pre-existing condition in COVID-19 deaths was ischemic heart disease, which was followed by dementia, chronic obstructive pulmonary disease, and diabetes. In all age categories, men exhibited a higher prevalence of comorbidities than women. In both sexes, the likelihood of having hypertension, diabetes, or chronic renal disease increased with age. Women over 85 years old had the highest

frequency of dementia. The study emphasizes how crucial it is to recognize and treat comorbidities in those who are at risk of having serious COVID-19 outcomes.

Frontera, J.A. et al. (2022), their study investigated whether COVID-19 patients with cognitive dysfunction had elevated levels of blood biomarkers of neuronal and glial injury, and whether these biomarkers were associated with in-hospital mortality and reduced rates of discharge home. The study found that COVID-19 patients with cognitive dysfunction had significantly higher levels of neurodegenerative biomarkers compared to COVID-19 patients without cognitive dysfunction, and these elevated biomarker levels were associated with a higher risk of in-hospital death and reduced rates of discharge home. The study also found that neurodegenerative biomarker levels in hospitalized COVID-19 patients were higher compared to non-COVID controls with varying degrees of cognitive impairment, suggesting that COVID-19 may cause brain injury.

Bhaskaran, K. et al. (2021), noted that they investigate how specific factors are differentially associated with COVID-19 mortality compared to mortality from causes other than COVID-19. The researchers carried out a cohort study using primary care data from England linked to national death registrations. They included all adults aged 18 years or older in the database on 1st February 2020 with over one year of continuous prior registration, and the cut-off date for deaths was 9th November 2020. The study found that most factors associated with COVID-19 death were similarly associated with non-COVID death, but the magnitudes of association differed. Older age was more strongly associated with COVID-19 death than non-COVID death, as was male sex, deprivation, obesity, and some comorbidities. Smoking, history of cancer, and chronic liver disease had stronger associations with non-COVID than COVID-19 death. All non-white ethnic groups had higher odds of COVID-19 death than white individuals but lower odds of non-COVID death. The study suggests that COVID-19 largely multiplies existing risks faced by patients, with some notable exceptions. The researchers emphasize the need to identify the unique factors contributing to the excess COVID-19 mortality risk among non-white groups to inform efforts to reduce deaths from COVID-19.

Wouterse, B. et al. (2023) Their study found that the COVID-19 pandemic led to an increase in income-related inequality in all-cause mortality in the Netherlands in 2020. This increase in

inequality resulted from the combination of COVID-19 mortality, which was more unequally distributed than predicted total mortality, and the inequality in non-COVID causes, which was less unequal than predicted. In other words, the pandemic disproportionately affected individuals with lower incomes and this led to an increase in overall inequality in mortality. Additionally, the displacement of deaths from other causes by COVID-19 may have also contributed to this increase in inequality.

Kliber, A. and Rychłowska-Musiał, E. (2023), from March 2020 to February 2021, an analysis of the links between COVID and non-COVID mortality, the severity of limitations, and healthcare spending in 31 European economies was conducted. The study concludes that despite governments' efforts to modify regulations to the rising fatality rate, they failed to stop the epidemic. The second sub-period had the largest weekly changes in non-COVID deaths in Central and Eastern European nations with lower government healthcare spending per capita. According to the study, healthcare spending can distinguish across nations.

Kliber, A. and Rychłowska-Musiał, E. (2023), In addition to a high number of deaths, mainly among older Americans, the COVID-19 pandemic also had an indirect effect on mortality from other causes among people of working age. According to this data, heart disease and external causes were the main causes of death in men between the ages of 25 and 64 who died of non-COVID excess, with the majority of these deaths occurring in the working age group. Alzheimer's disease and cerebrovascular disease were also substantial causes of non-COVID excess mortality in females. For Americans in their 20s and 30s, the closing of day-care centres and schools made the conflicts between work and family life much worse. The data also reveals an increase in mortality from a various causes, such as diabetes, unintentional injuries, Alzheimer's, stroke, influenza, and pneumonia, as well as heart disease, but a drop in suicide and chronic lower respiratory disease fatalities. According to the data, there were differences in excess mortality by sex and age group, with young and middle-aged Americans—particularly men—taking the brunt of the pandemic's financial effects.

Williamson, E.J. et al. (2021), they discussed the higher mortality rate and the uncertainty surrounding the increased risk for individuals with milder kinds of learning disabilities among

people with learning disabilities in England. They also talked about the increased risk of severe outcomes from COVID-19. Underlying medical issues, living situations, difficulties with physical distance, and difficulty understanding protective measures are all factors that raise the risk. The article also mentions that some, but not all, people with learning difficulties were included in the national recommendations for prioritizing COVID-19 vaccination in England. The study's main finding was that people with learning disabilities have a significantly higher risk of COVID-19-related hospital admission and death compared to the general population. It used linked electronic health records to describe the risk of COVID-19-related hospital admissions and deaths among children and adults with learning disabilities in England.

Cronin, C.J. and Evans, W.N. (2021), In this study, extra mortality in the US during the COVID-19 pandemic is investigated, and the burden of excess mortality is calculated for each ethnic group, age group, and gender. According to the study, 34% of the extra years of life lost by males are due to excess mortality from non-COVID-19 causes, which is particularly high among men and non-Hispanic Black men. While minorities represent 36% of COVID-19 deaths, they represent 70% of non–COVID-19 related excess deaths and 58% of non–COVID-19 excess life years lost. Black, non-Hispanic males represent only 6.9% of the population, but they are responsible for 8.9% of COVID-19 deaths and 28% of 2020 excess deaths from non–COVID-19 causes. The study documents that the life years lost from non–COVID-19 excess death is heavily concentrated in minority men.

Lau, V.I. et al. (2022), The COVID-19 pandemic has resulted in extensive disruption of non-urgent healthcare services and a change in the health system's priorities, which could have detrimental effects on patients with illnesses other than COVID. There were considerable increases in mortality, morbidity, acute care hospitalizations, and disruptions to standards-of-care for non-COVID illnesses, according to a systematic review and meta-analysis of the pandemic's effects on non-COVID outcomes.

Gasch-Illescas, A. et al. (2023), The high excess mortality seen during the first wave of COVID-19 in the south of Spain in the spring of 2020 is discussed in the paper. The investigation primarily focuses on admissions, mortality, risk factors for non-COVID mortality, and alterations in the non-

COVID patient profile from a significant Andalusia hospital region. According to the study, the additional mortality cannot simply be attributed to the virus's ability to kill more or less susceptible persons, but also to the pandemic's side effects and the load they placed on healthcare delivery and infrastructure. The study emphasizes the need of assessing COVID-19's direct and indirect effects on mortality as well as the necessity for future public health initiatives, care planning, and resource management in hospitals for the handling of pandemics or crises of a similar nature.

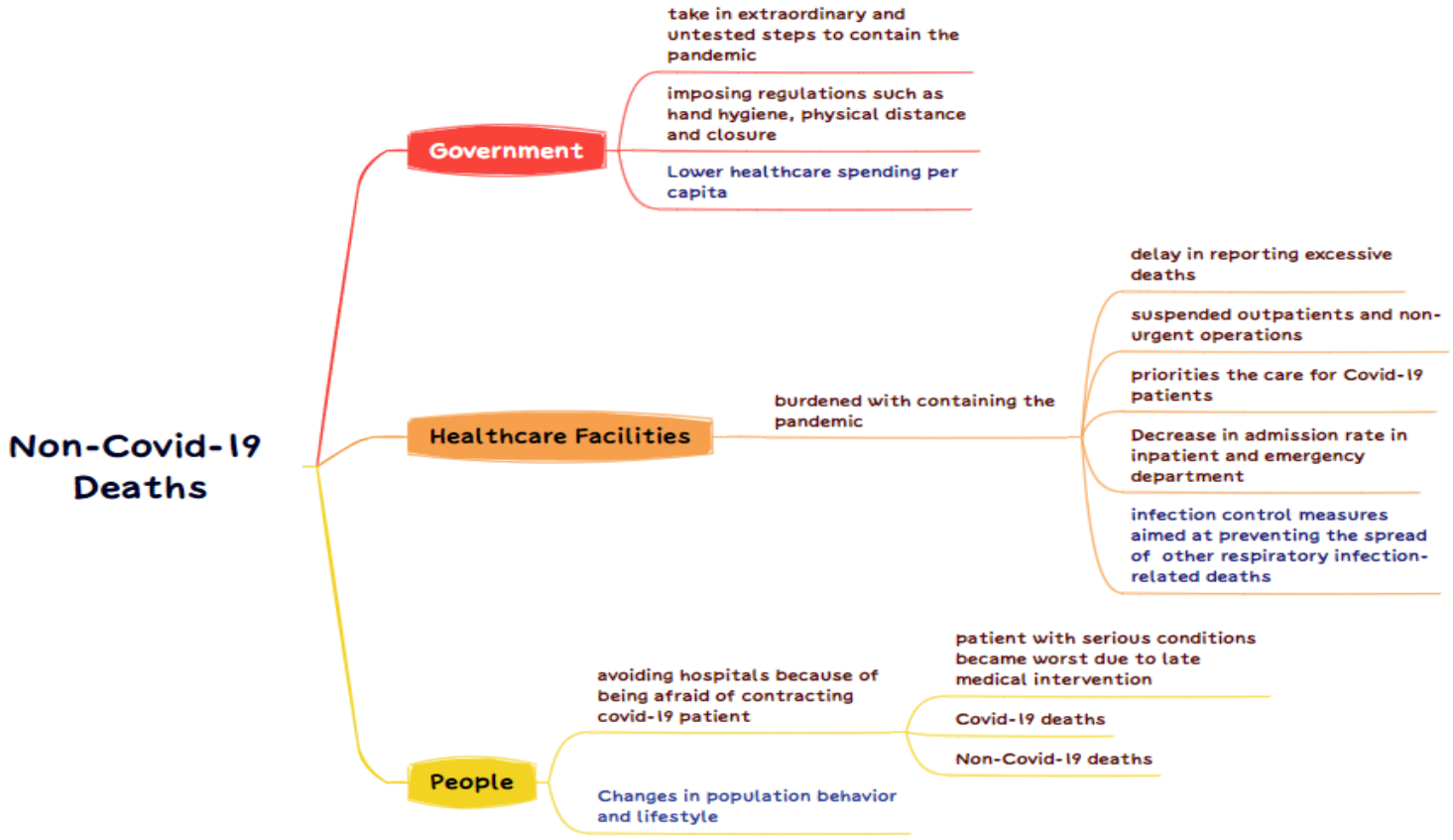


Figure 2:Literature Mind map

Takeaways from Literature Review:

- Governments in all over the world take in extraordinary and untested steps to contain the pandemic, they imposed regulations such as hand hygiene, physical distance, and closure.

- Healthcare facilities were burden end with containing the pandemic which causes delay in reporting excessive deaths, suspended outpatients and non-urgent operations, priorities the care for Covid-19 patients as a consequence of that the number of admissions decreases in inpatient, outpatient and emergency department.
- People was avoiding hospitals because of being afraid of being afraid of contracting Covid-19 patient which causes serious conditions to become worst due to late medical intervention, Covid-19 deaths and Non-Covid-19 deaths.
- Cities that are less developed was affected by Covid-19 more than the developed cities due to the weak infrastructure and the collapse of the health system.
- Some studies suggests that infection control measures aimed at preventing the spread of other respiratory infection-related deaths.
- The study suggests that the changes in population behaviour and lifestyle during the lockdown brought about unforeseen health benefits, which was a decrease in Non-Covid-19 deaths.
- there have been significant and historic non-Covid health harms in the United States during the pandemic, resulting in excess deaths and a loss of well over $1 trillion.
- The pandemic has caused significant non-Covid health harms in the US, resulting in excess deaths and a higher mortality rate for working-age adults, with causes including drugs, homicides, traffic fatalities, and alcohol-induced deaths.
- The study found that ischemic heart disease was the most common pre-existing condition in COVID-19 deaths, men had a higher prevalence of comorbidities than women in all age groups, and the prevalence of hypertension, diabetes, and chronic kidney disease increased with age in both sexes.
- The study found that despite governments' efforts to modify regulations to the rising fatality rate, healthcare spending can distinguish across nations, and lower healthcare spending per capita in Central and Eastern European nations was associated with larger weekly changes in non-COVID deaths during the second sub-period of the COVID-19 pandemic.
- Excess mortality from non-COVID-19 causes is substantial among males and minorities, particularly Black, non-Hispanic males, and represents a significant portion of the excess life years lost during the pandemic.

Chapter 3

Data Analysis

3.1 Data Understanding

This research is premised on the hypothesis that Covid-19 pandemic has resulted in excessive death unrelated to Covid-19 due to people's fear contracting covid-19, in addition to that, healthcare facilities have been overburdened with containing this pandemic and this might be another reason for not providing the proper care for them. Therefore, covid-19 pandemic affected non-covid1-9 deaths rate in UAE. To obtain accurate data to analyse the impact of non-Covid-19 deaths on UAE, the competent authority was sought, which is the Emirates Healthcare Services (EHS).

Emirates Healthcare Services owns the data, which collected by an electronic system called Wareed, it's facilitating the process of data collection, allowing the collection of structured and specific information in a systematic manner, thus enabling to perform data analysis on the information in order to answer the required questions.

For this project, there are four types of data:

- The first dataset contains 19 variables, and 6020 rows as follows:

Table 2 Variables description in Deaths Dataset

#	Variables	Description	Variable Type
1	Patient code	A unique identifier assigned to each patient.	Categorical – Nominal
2	Nationality	The nationality of the deceased patient	Categorical – Nominal
3	Sex	The gender of the deceased patient	Categorical – Nominal
4	Age	The age of the patient at the time of the deceased time	Numeric – Continuous
5	Encounter Type	The type of encounter	Categorical – Nominal
6	Diagnosis Responsible Provider	The healthcare provider responsible for diagnosing the deceased patient.	Categorical – Nominal

7	Diagnosis Classification	The classification of the diagnosis	Categorical – Nominal
8	Actual Diagnosis Code	The code assigned to the patient's diagnosis	Categorical – Nominal
9	Actual Diagnosis Description	A description of the patient's diagnosis	Categorical – Nominal
10	Leading Diagnosis Code	The code assigned to the patient's primary diagnosis	Categorical – Nominal
11	Direct Diagnosis Description	A description of the patient's primary diagnosis.	Categorical – Nominal
12	Encounter ID	It is a unique identifier to link different observations to the same individual	Categorical – Nominal
13	Encounter Type	It is the patient location such as (inpatient, outpatient, Emergency, Dialysis, Etc)	Categorical – Nominal
14	Discharged Type	It's described the discharge type (Deceased, Deceased on Arrival, discharged still birth, Discharged stillborn)	Categorical – Nominal
15	Diagnosis Data & Time	Diagnose Date & time	Numerical
16	Admit Data & Time	Admission Date & time to the hospital	Numerical
17	Discharged Date &Time	Discharged Date & time from the hospital	Numerical
18	Facility	The facility the patient died in.	Categorical – Nominal
19	Building	Identifying which building in the facility	Categorical – Nominal

- The second table contain the number of patients in inpatient Department from 2018 to 2020

Table 3 Inpatient Department Dataset

#	Variables	Description	Variable Type
1	Month	The month and the year of patient visit to the hospital	Categorical – Nominal
2	Patient count	Number of patients visit to the hospital in each month of the year	Numerical

- The third table contain the number of patients in outpatient Department from 2018 to 2020

Table 4 Outpatient Department Dataset

#	Variables	Description	Variable Type
1	Month	The month and the year of patient visit to the hospital	Categorical – Nominal
2	Patient count	Number of patients visit to the hospital in each month of the year	Numerical

- The fourth table contain the number of patients in Accident & Emergency Department from 2018 to 2020

Table 5 Accident & Emergency Department Dataset

#	Variables	Description	Variable Type
1	Month	The month and the year of patient visit to the hospital	Categorical – Nominal
2	Patient count	Number of patients visit to the hospital in each month of the year	Numerical

To gain a better understanding of the data characteristics, data summary and visualization will be performed as follows:

3.2 Dataset Summary

The dataset contains 19 variables, with 15 variables being categorical and requiring the use of frequency summaries. The remaining variables are categorical with multiple values and cannot be summarized. Conducting a statistical summary can provide valuable insight into the data, including measures such as the mean, median, and standard deviation.

```
New names: Patient Code       Nationality            Sex
 Length:6020        Length:6020        Length:6020
 Class :character   Class :character   Class :character
 Mode  :character   Mode  :character   Mode  :character


 Age- Years (Visit) Old Encounter Type...5 Diagnosis Responsible Provider
 Min.    :  0.00        Length:6020        Length:6020
 1st Qu.: 35.00        Class :character   Class :character
 Median : 53.00        Mode  :character   Mode  :character
 Mean   : 51.93
 3rd Qu.: 71.00
 Max.   :118.00
 NA's   :4
 Diagnosis Classification Actual Diagnosis Code Actual Diagnosis Description
 Length:6020              Length:6020           Length:6020
 Class :character         Class :character      Class :character
 Mode  :character         Mode  :character      Mode  :character


 Leading Diagnosis Code Leading Diagnosis Description Direct Diagnosis Code
 Length:6020            Length:6020                   Length:6020
 Class :character       Class :character              Class :character
 Mode  :character       Mode  :character              Mode  :character


 Direct Diagnosis Description Encounter Id       Encounter Type...15
 Length:6020                  Length:6020        Length:6020
 Class :character             Class :character   Class :character
 Mode  :character             Mode  :character   Mode  :character


 Discharge Disposition Diagnosis Date & Time
 Length:6020           Min.   :2018-12-20 10:15:05.00
 Class :character      1st Qu.:2019-07-11 12:32:09.00
 Mode  :character      Median :2020-01-28 18:36:06.00
                       Mean   :2020-01-11 23:44:02.21
                       3rd Qu.:2020-06-25 15:37:21.00
                       Max.   :2021-01-10 13:31:05.00
                       NA's   :2851
 Admit Date & Time             Discharge Date & Time
 Min.   :2011-02-20 13:00:00.00   Min.   :2017-01-01 18:11:00.00
 1st Qu.:2018-01-19 08:09:00.00   1st Qu.:2018-01-28 08:57:45.00
 Median :2019-02-18 12:36:05.00   Median :2019-03-01 00:30:19.50
 Mean   :2019-01-22 06:57:19.61   Mean   :2019-02-05 18:43:56.08
 3rd Qu.:2020-02-23 22:39:22.75   3rd Qu.:2020-03-01 19:24:20.00
 Max.   :2020-12-31 17:20:19.00   Max.   :2020-12-31 22:56:45.00
 NA's   :4
   Facility           Building
 Length:6020        Length:6020
 Class :character   Class :character
 Mode  :character   Mode  :character
```

There are 19 columns in the dataset, few keys are identified based on the initial analysis,

- In the age variable, the minimum Age of the died patients is 0 and the maximum is 118, the mean is 51 and the median is 53, it seems that we have a normal distribution of the ages, there are no outliers (Figure 1) and 4 missing values (Figure 2)
- There are 3 numerical variables represented by date and time which are (Diagnose date & time, admission date & time, and discharged date & time), the discharged date column considered as the death date to build the analysis based on it.
- The rest variables are categorical, and it contain a lot of missing values (Figure 2).

The data was pulled from Wareed's electronic system, the initial observation suggest that the data may require some cleaning.

It is important to highlight that the dataset contained several duplicated records that required careful removal, as this could have an impact on the analysis. So the number of records was 6020 after the cleaning it become 5665.

In addition to the fact that the gender column contains 8 cases recorded as unknown, the data has been reviewed to find an explanation for it, 7 cases of new-borns whose age is mostly zero were found as they were registered in the system and there is another case whose gender was identified as unknown.

The second, third, and fourth datasets were compiled into one sheet, representing the monthly number of patients in hospital departments, including Inpatient, Outpatient, and Accident & Emergency, from 2018-2020. A statistical summary was performed, revealing significant variation in the Mean, Median, Standard Deviation, minimum and maximum number of patients in the three departments. Further analysis is required to determine the significance of this variation.

```
        Months     Inpatients          AE              OPD
 2018-01-01: 1   Min.   :4372   Min.   :23243   Min.   : 35710
 2018-02-01: 1   1st Qu.:6132   1st Qu.:47287   1st Qu.: 82081
 2018-03-01: 1   Median :6826   Median :55053   Median :103029
 2018-04-01: 1   Mean   :6618   Mean   :51355   Mean   : 95244
 2018-05-01: 1   3rd Qu.:7109   3rd Qu.:59471   3rd Qu.:110188
 2018-06-01: 1   Max.   :7809   Max.   :69509   Max.   :121022
 (Other)   :30
[1] 760.7426
[1] 20736.74
[1] 12242.37
```

Outliers

To find if there are any outliers in the first dataset a boxplot is made, the plot shows that there are no outliers in the (Age) variable, the rest variables are categorical so no need to check for outliers (Figure 2).

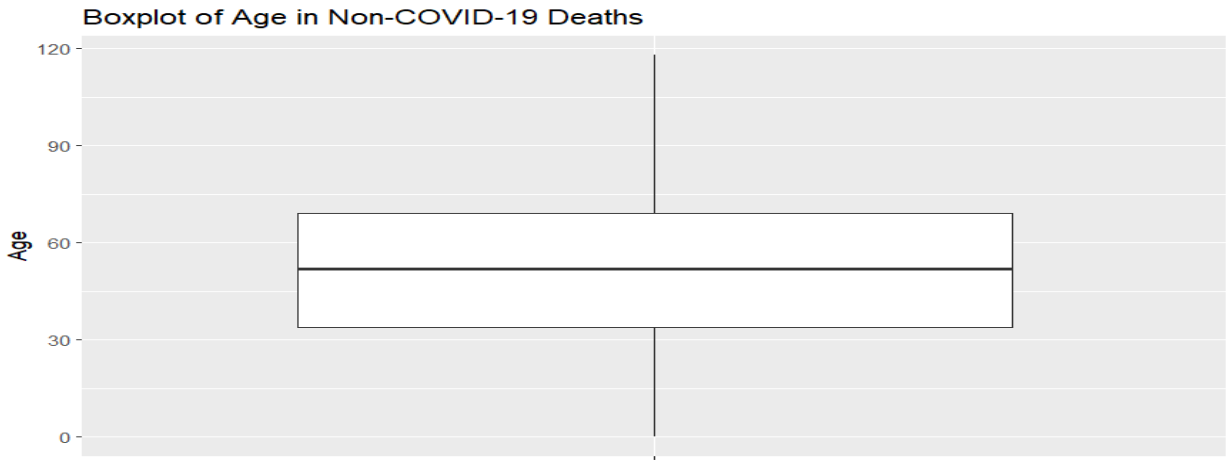


Figure 3. Boxplot of Age in Non-Covid-19 Deaths

The second, third and fourth datasets was compiled in one sheet, these data represent the number of patients in hospital departments which are Inpatient, Outpatient and Accident &Emergency from 2018-2020), a boxplot was created to find if there are any outliers, the plot shows that there are are outliers in Inpatient department, OPD (Outpatient) and AE (Accident & Emergency department (Figure 3), these outliers represent the number of patients visits to the hospital departments during Covid-19 pandemic .

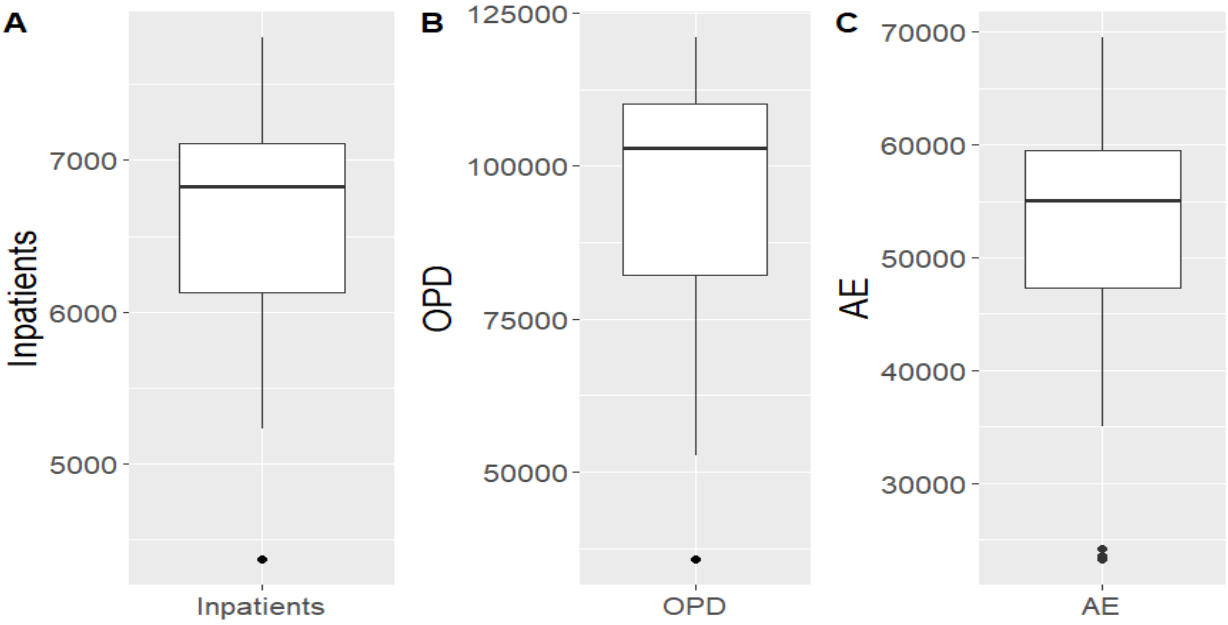


Figure 4. Boxplot for Inpatient, OPD, AE

Missing values:

There are three missing values in the Age column. Since all the data is categorical except the age column It turns out that there is no outlier in this column.

With regard to the other columns that do have missing values, this is because the causes of death were recorded manually, but during the year 2020, the electronic registration of the causes of death and the issuance of certificates were fully adopted from the electronic system as depicted in the Figure 5.

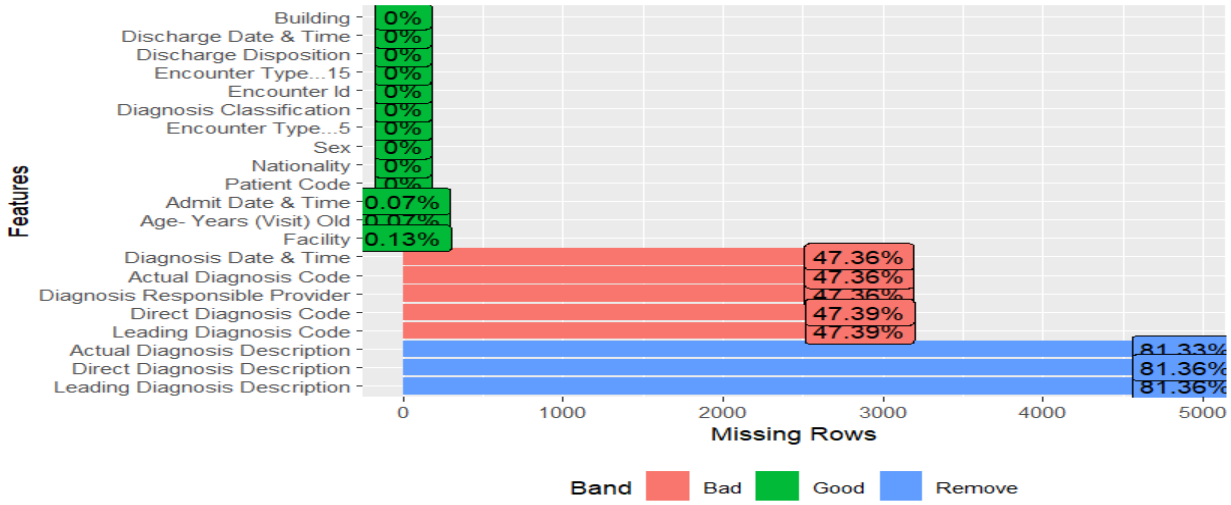


Figure 5. Missing values in Data features before the data cleaning

Overall, these initial observations suggest that the data may require some cleaning and pre-processing before performing more in-depth analyses in this dataset.

For the monthly number of patient's admissions for the hospital departments (Inpatient, Outpatient and Accident and Emergency the dataset is clean without any missing values.

3.3 Dataset Exploration

To explore the dataset many charts have been prepared to get an overview of the data. First, a line charts was used to research whether there is any trend or an increase in deaths from causes other than Covid-19 for the period 2018 to 2020, it is noted that there was a slight increase in deaths during the year 2020 (Figure 5). When digging deeper into the data, it was found that this increase was especially during the first wave of Covid-19, that is, almost During the second quarter of 2020 (Figure 6).

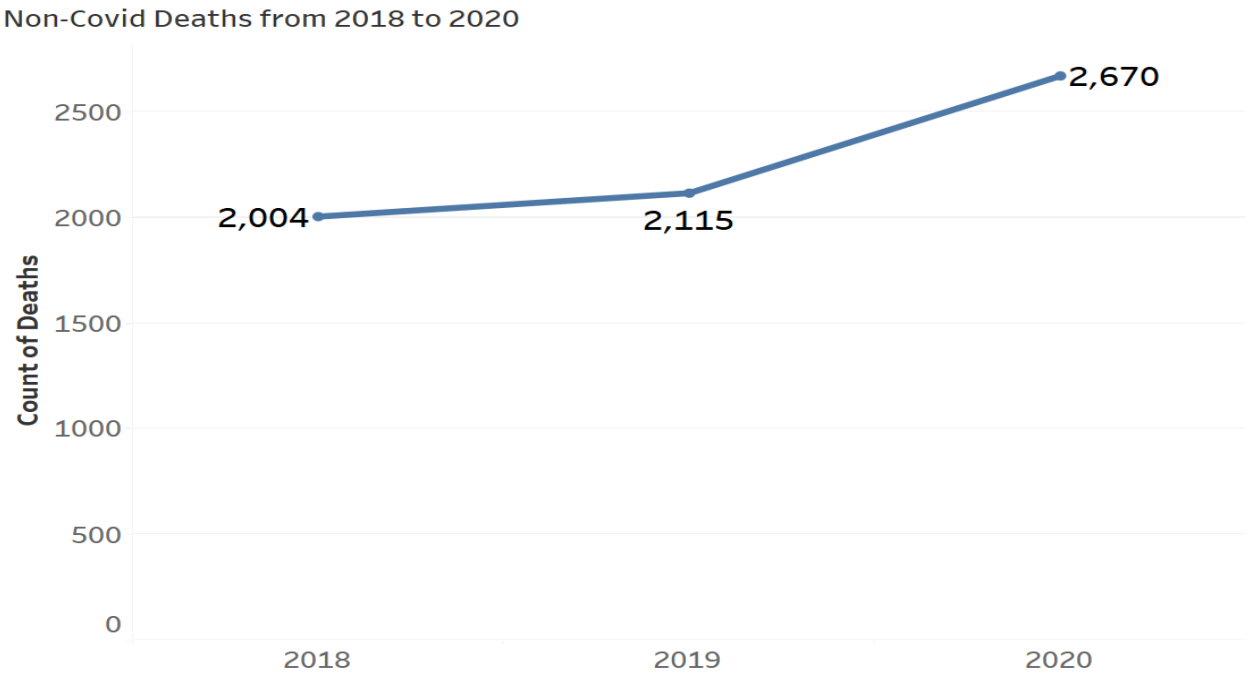


Figure 6. Non-Covid-19 Deaths from 2018-2020

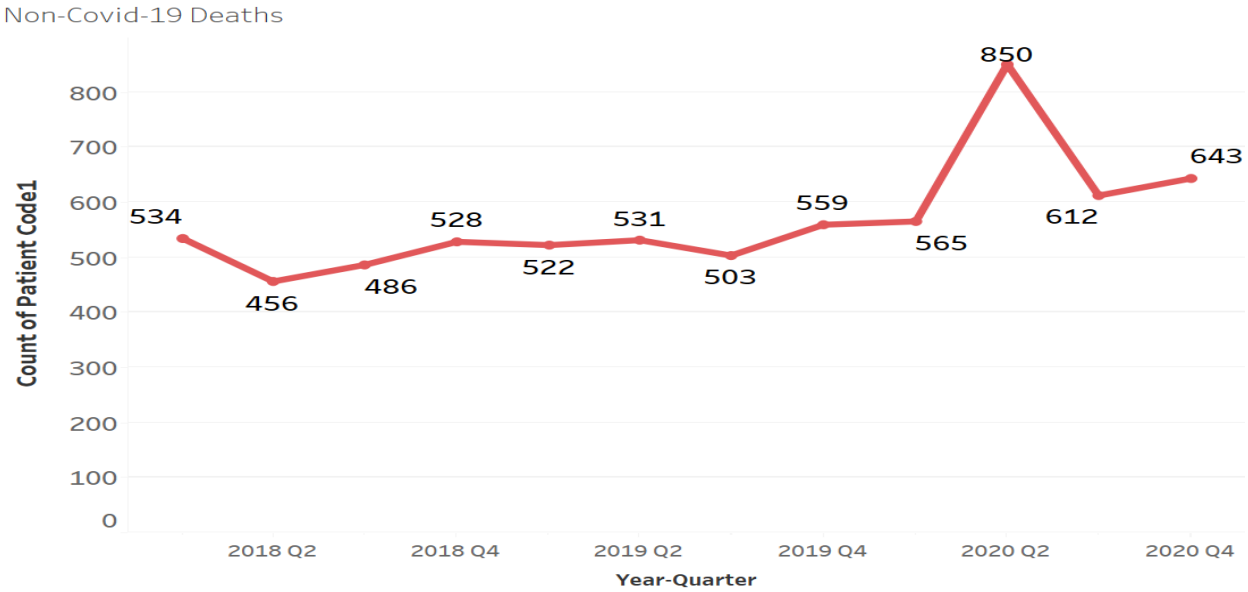


Figure 7. NonCovid-19 Deaths quarterly

Through the following bar graph which represent deaths per Sex, it was found that the majority of deaths that occurred from diseases other than Covid-19 were of the male category, they represented 72% of the total deaths (Figure 7).

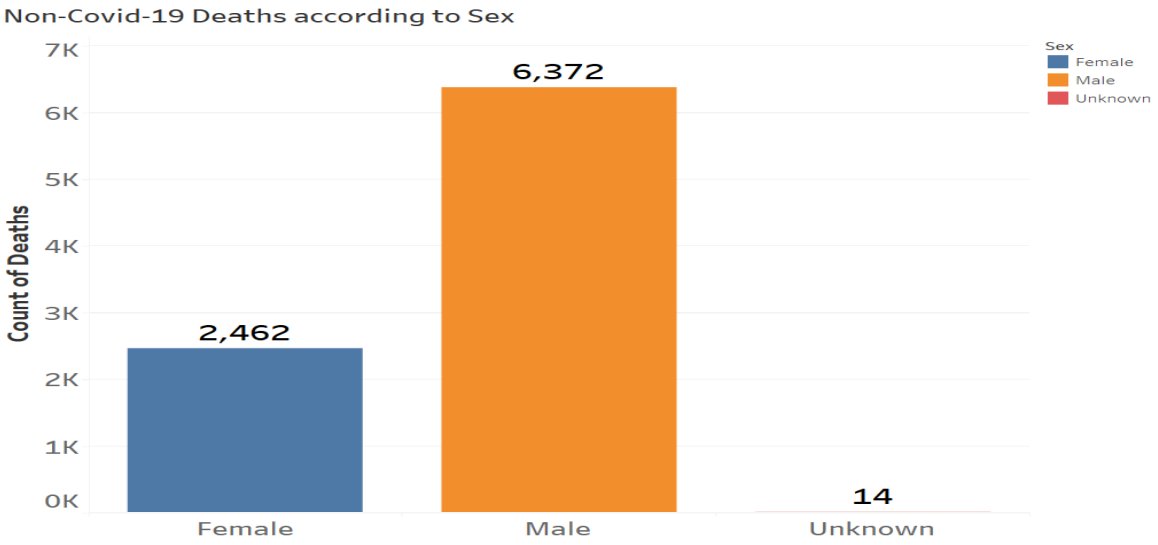


Figure 8 Non-Covid-19 Deaths according to Sex

To determine which nationality according to their sex has the highest number of deaths, a pie chart was performed (Figure 8), and the investigation revealed that the majority of the patients who passed away because of disease other than covid-19, regardless of their nationality, were male in both categories' citizen and non-citizen.

Among the citizen the male represents 56% while female represent 43%, In non-citizen category the male represents 79% while the female represents 21%.

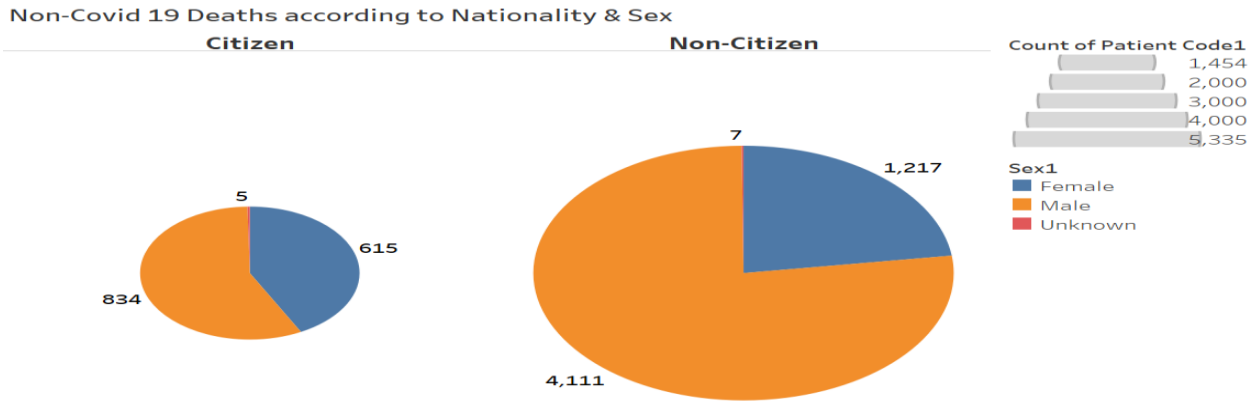


Figure 9. Non-Covid-19 Deaths according to Nationality & Sex

To determine the distribution of data according to age and nationality, several charts were made to understand the underlying factors driving the causes of Non-Covid-19 deaths. The following general view was drawn from the data:

- The age range of most deceased patients was approximately ranged between 35 to 70 years (Figures 9 and 10).
- Most of the deceased patients were males, the distribution shows two age categories, ages between of 35 and 55 years and new-born, also females' distribution showed two segments, dead females fall into either 69-83 Years old or age group zero (new-born) (Figure 11).
- Most of the citizen deaths fall into 76-83 Years old, while among non-citizens, the majority of deaths occurred among those between 35-55 Years old (Figure 12).

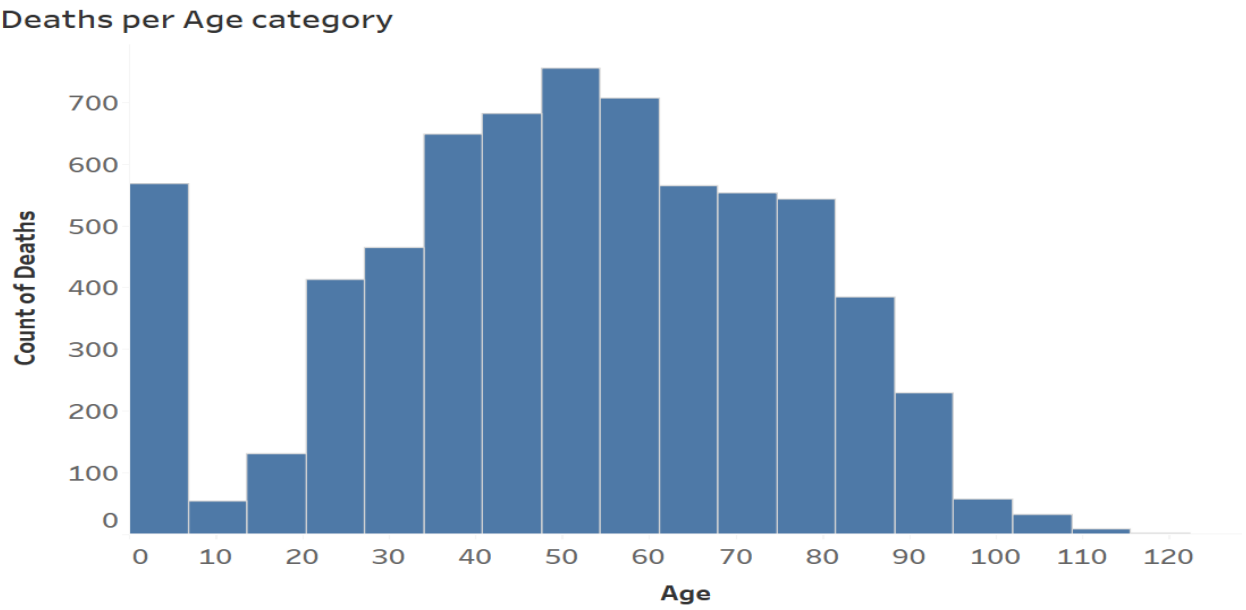


Figure 10. Non-Covid-19 Deaths per Age category

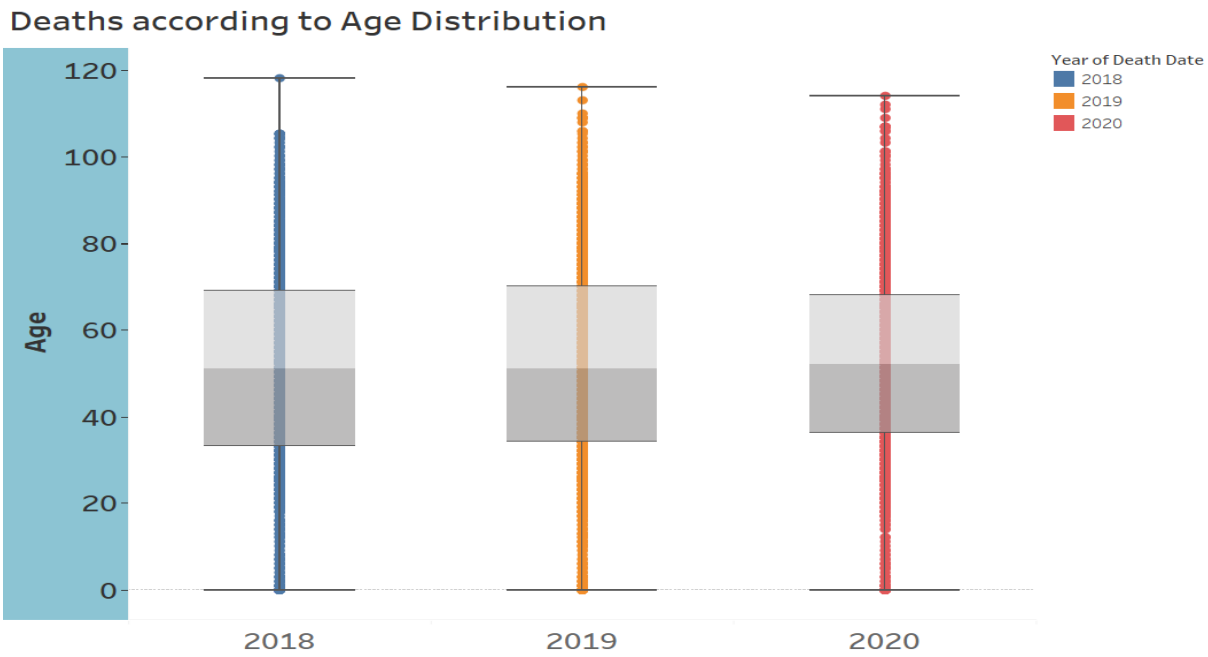


Figure 11. Covid-19 Deaths according to Age Distribution

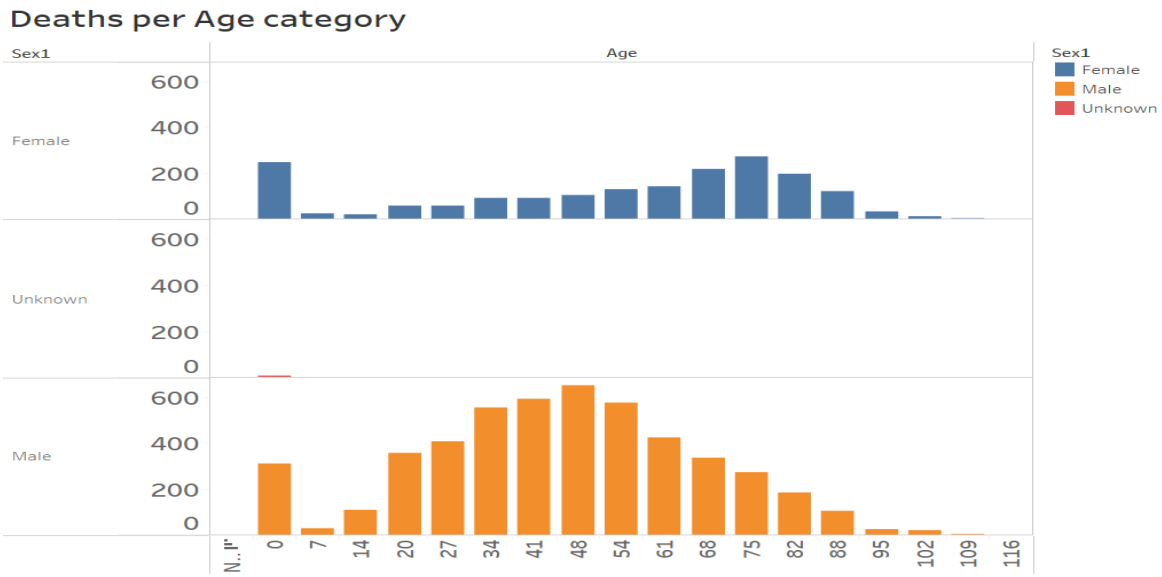


Figure 12. Non-Covid-19 Deaths per Age Category & Sex

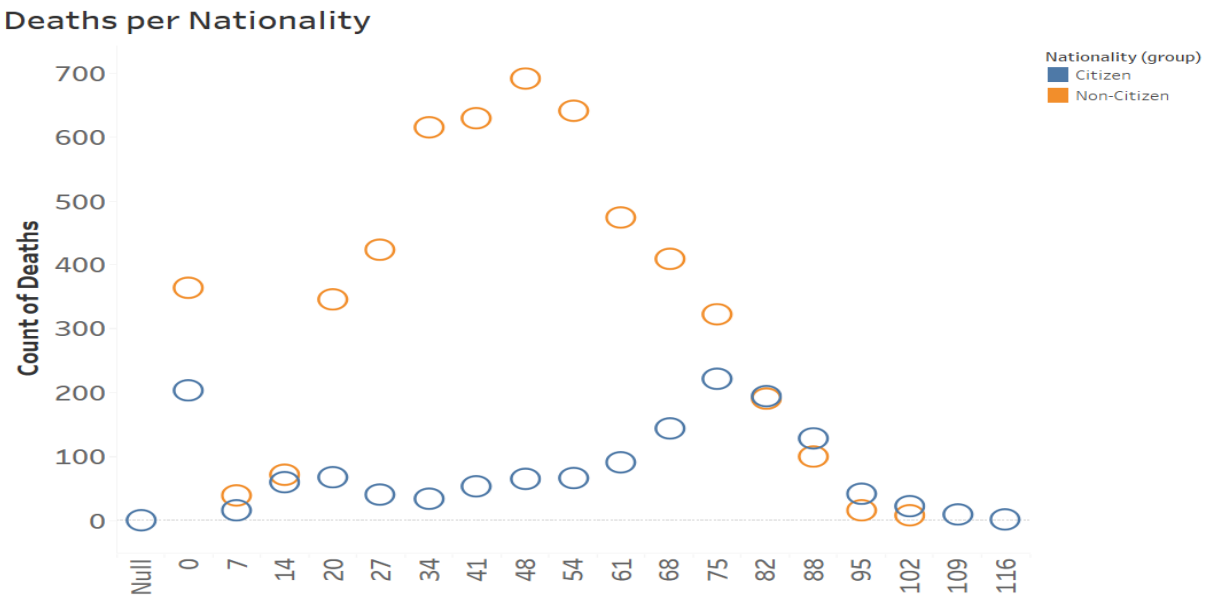


Figure 13. Non-Covid-19 Deaths per Nationality

From the other datasets that is representing the three departments (Inpatient, Outpatient, Accident & Emergency), a line chart was performed to find the if there's any trend in them, the below graph shows the number of patients admitted to three hospital departments (Inpatient, Outpatient, and Accident & Emergency) and the number of deaths during the pandemic period (Figure 13). It suggests that as the number of patients admitted to these departments decreases, the number of deaths increases.

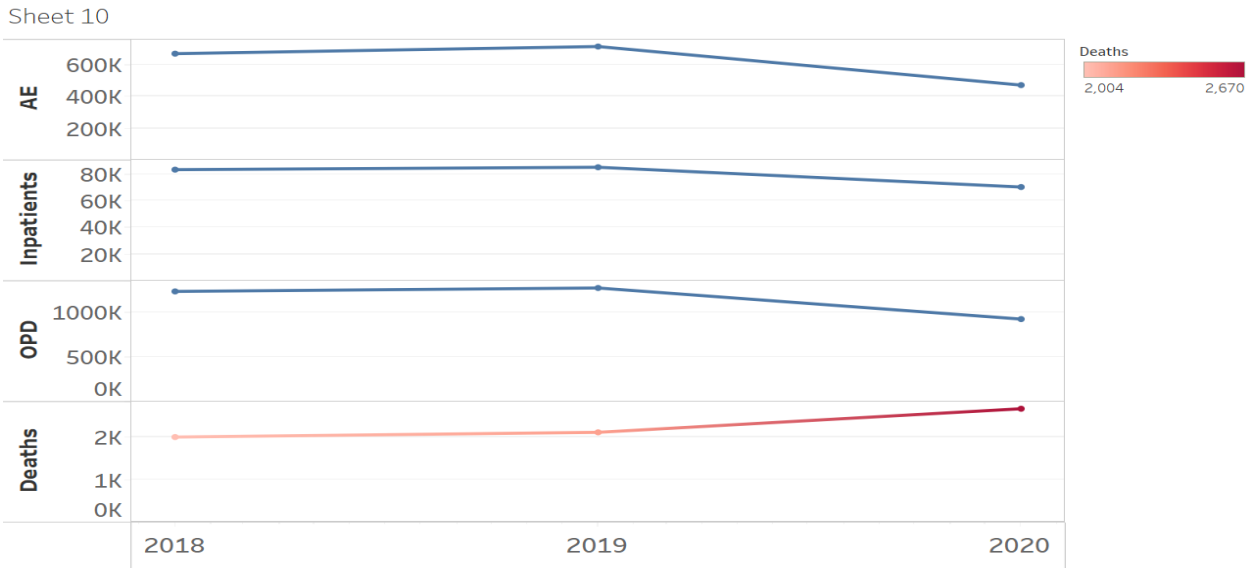


Figure 14. Non-Covid-19 Deaths from 2018-2020 in each hospital department

3.4 Data Preparation

To obtain a clear picture of the excessive deaths for other reasons than Covid-19 during the pandemic and to be able to answer the research questions, the dataset obtained from Emirates Healthcare Services (EHS) will be analysed, but before performing the analysis step the data must be prepared and cleaned in order to perform the analysis.

The first dataset that related to deaths needed the following cleaning:

- Replace the missing values in the Age column.
- define the variables that needed to answer the research questions.
- Delete the duplicated records.

The dataset contains all the deaths from 2018-2020, the cases were filtered according to the International Classification of Diseases coding (ICD-10 coding) and a column was added to classify deceased patients who died of COVID-19 disease were identifies as 1, while the cases that died of diseases other than Covid-19 were identified as (0). Finally, a column was added to classify the deceased as a citizen and non-citizens.

Delete unnecessary columns:

There are 13 columns will be deleted from the dataset to focus on the variable needed for the analysis which are:

Encounter Type, Diagnosis Responsible Provider, Diagnosis Classification, Actual Diagnosis Code, Actual Diagnosis Description, Leading Diagnosis Code, Direct Diagnosis Description, Encounter ID, Encounter Type, Discharged Type, Admit Data & Time, Diagnose Date &Time and Facility.

Missing values:

There are four missing values in the Age column, which is replaced by the mean age because the age group is homogeneous, and the mean and median have approximately the same values.

The other column don't have any missing values.

This graph shows that there are no missing values in Age column after replacing it with the age mean (Figure 12).

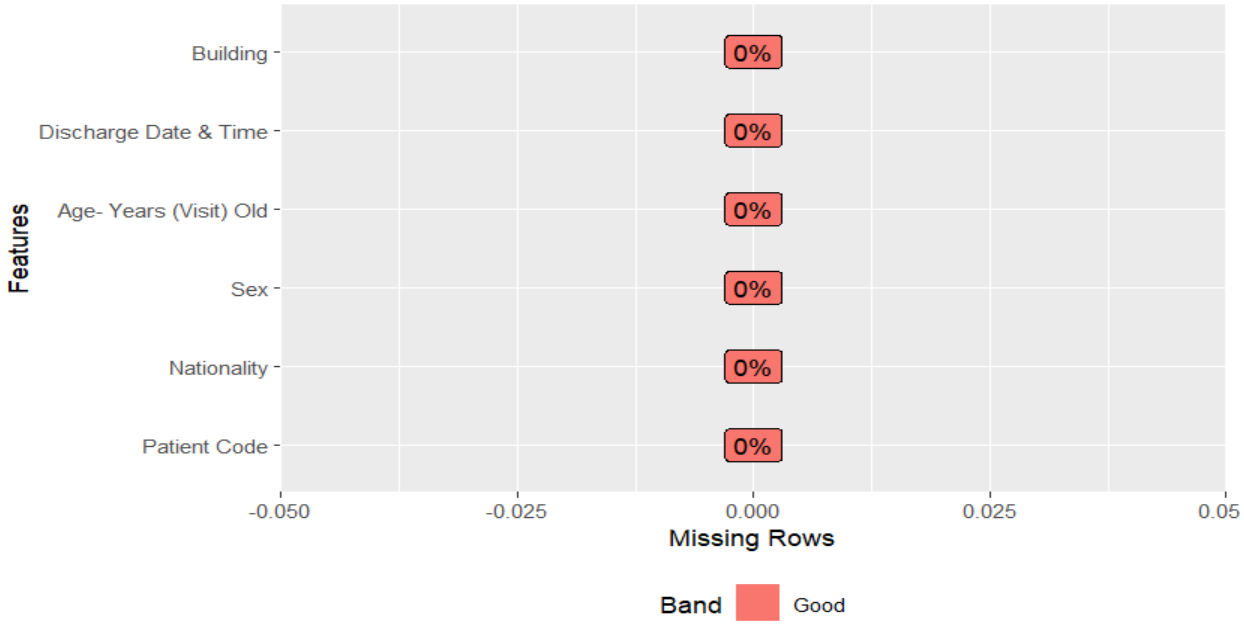


Figure 15. Missing values for the data variables after the cleaning process

Delete the duplicated records:

Upon inspecting the data, multiple duplicated records were identified and were manually removed to ensure that only the appropriate records were retained in the dataset. The number of rows after the cleaning process is 5665.

3.5 Data Modeling and Evaluation

The next step is to model the dataset and explore it to gain a better understanding of the problem. Subsequently, an appropriate statistical learning method will be selected to analyse the data and provide evidence-based insights into whether there were excessive non-COVID-19 deaths during the COVID-19 pandemic.

Statistical learning is a more traditional approach to data analysis that is based on statistical models and methods. The goal of statistical learning is to understand the underlying relationships between variables in the data and to use that understanding to make predictions or draw conclusions about the data. Statistical learning methods are often used in applications such as hypothesis testing, linear regression, and time series analysis. One key difference between machine learning and statistical learning is the focus on prediction versus inference. Machine learning algorithms are typically designed to optimize the accuracy of predictions, while statistical learning methods are often more concerned with understanding the underlying relationships between variables in the data.

To evaluate the effectiveness of the models, several statistical methods can be used in the Evaluation phase. These methods can assess the quality of the model. Here are a few common evaluation techniques that will be used:

3.5.1 T-Test Method

- T-test method, it will be used to compare the means of two groups and determine if they are significantly different. There will be several comparisons between the means of two groups, they are Non-Covid-19 deaths before and during the pandemic, the number of admission to the three hospital departments (Inpatient, Outpatient, Accident & Emergency)

before and during the pandemic. To evaluate the effectiveness of t-test, p-value will be calculated for each comparison of means, if the p-value is less than the threshold (0.05) then It can be concluded that that there is a significant difference between the means of the two groups being compared.

3.5.2 Logistic Regression

- Logistic Regression, this method will be used to find the important predictors of the likelihood of death. This method can be used to test the relationship between the dependent variable which is Non-Covid-19 deaths and the predictor variables which are age, nationality, and sex.

3.5.3 Multiple Linear Regression

- Multiple Linear Regression method, it will be used to find if the important predictors that affect Non-covid-19 deaths during the pandemic, the dependent variable in this case the monthly number of non-covid-19 deaths and multiple independent variables which are monthly number of inpatient, outpatient and accident & emergency. This method can be applied if all the variables are numerical.

3.5.4 Percentage Difference approach (P-score)

- In this case, the goal of the analysis is to determine if there is a difference in the number of deaths between 2020 and the average of deaths from 2018-2019. One common approach to measure this difference is the P-score, also known as the "observed-to-expected deaths ratio," it compares the number of deaths actually recorded during a certain time period with the number of deaths expected in according to previous data or a predetermined baseline. A P-score larger than one implies excess mortality, which is when more deaths are observed than are predicted. Less deaths were seen than anticipated when the P-score was less than one.

  The formula for calculating the P-score is:

  P-score = Observed deaths / Expected deaths

Numerous techniques, including historical information, demographic data, or disease-specific models, can be used to determine the expected death rate. The P-score can aid in understanding the effects of a public health crisis on a population and informing policy decisions for public health officials and researchers. It also enables comparisons across countries.

3.6 Research questions findings

To answer the research questions, statistical methods and machine learning methods will be used:

Research question 1: What is the rate of non-Covid-19 deaths in UAE?

The death rate results for non-COVID-19 deaths per 100,000 population[(25)] during the years 2018-2020 show that the yearly death rate changed between 2018-2019 and 2020 by 31.18%, as follows:

Year <dbl>	Yearly_Death_Rate per 100,000 population <dbl>
2018	21.57788
2019	22.96004
2020	29.21171

It is not surprising to see an increase in the death rate during the COVID-19 pandemic, as it has affected many people worldwide. The increase in the death rate in the second quarter of 2020 is likely due to the peak of COVID-19 cases and deaths that occurred during that time, as shown in the table below:

Table 6. Statistics of Total patients visited the hospitals and number of deaths quarterly from 2018-2020

Months	Quarterly Deaths Rate per 100,000 population
Q1-2018	5.842
Q2-2018	4.989
Q3-2018	5.317
Q4-2018	5.777
Q1-2019	5.667
Q2-2019	5.764
Q3-2019	5.460
Q4-2019	6.068
Q1-2020	6.084
Q2-2020	**9.152**
Q3-2020	6.590
Q4-2020	6.923

To measure the change in deaths, the percentage difference approach (P-score) will be used. it will be calculated using R to determine the excess mortality or deviation of observed mortality from the expected mortality based on the historical data.

```
Expected deaths: 1731.538
Observed deaths: 2287
P-score: 1.320791
```

A P-score greater than 1 indicates that more deaths were observed than expected. In this case, the P-score of 1.320791 indicates that there were 1.320791 times as many observed deaths as expected based on historical data.

To convert this into a percentage, (1) will be subtracted from the P-score and multiplied by (100):

Percentage increase = (P-score - 1) * 100 = (1.320791 - 1) * 100 = 32.1%

Therefore, the P-score of 1.320791 indicates that the observed number of deaths was about 32.1% higher than the expected number of deaths based on the historical data.

The mean difference between the Non-Covid-19 death counts in the two periods (Jan 2018-Feb 2020) and (Mar 2020 – Dec 2020) was found by calculating the P-score. These results indicate that the observed number of deaths was about 32.1% higher than the expected number of deaths based on the historical data which is corresponding to the previous results.

Research question 2: Is there a significant difference in non-Covid-19 mortality rate between 2020 and 2018-2019?

This difference in non-Covid-19 mortality rate between 2020 and 2018-2019 will be proved by using Welch Two Sample t-test as follows:

H_0 -Null hypothesis–- there is no significant difference in non-Covid-19 mortality rate between (Mar 2020- Dec2020) and (Jan 2018 to Dec 2020).
H_A- Alternative hypothesis–- there is a significant difference in non-Covid-19 mortality rate between (Mar 2020- Dec2020) and (Jan 2018 to Dec 2020).

To test whether there was a significant increase in non-Covid-19 deaths during (March 2020–-December 2020) compare it with previous years (January 2018 to February 2020), Welch's t-test was performed again to test the pandemic impact on Non-Covid-19 deaths during the entire year of 2020

```
        Welch Two Sample t-test

data:  Count_of_Deaths_from_Jan_2018_Dec2020$`Deaths from Jan 2018-Feb2020`
and Count_of_Deaths_from_Jan_2018_Dec2020$`Deaths from Mar-Dec 2020`
t = -3.6045, df = 9.7909, p-value = 0.004978
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -89.98166 -21.11065
sample estimates:
mean of x mean of y
 173.1538  228.7000
```

The p-value of 0.004978, which is less than the standard threshold of 0.05, indicates that there is a significant difference between the means of the two groups.

This conclusion is also supported by the confidence interval of [-89.98166, -21.11065], which does not contain the value of 0 that indicates a significant difference between the means of the two groups.

The number of Non-Covid-19 deaths during the pandemic, which is from Mar to Dec 2020, is therefore significantly higher than the number of deaths from Jan to Feb 2020, according to these findings.

As a result, these findings show that the number of Non-Covid-19 deaths increased significantly during the pandemic.

Research question 3: How to determine the relationship between the occurrence of non-Covid-19 deaths and other covariates, e.g., nationality, gender, and age?

In order to find the demographic features that has an association with the non-covid-19 deaths, Logistic Regression analysis have been conducted as follows:

H_0 -Null hypothesis–- participants' demographic features or other factors has no association with non-Covid-19 deaths.

H_A - Alternative hypothesis -there is significant association between participants' demographic factors and non-Covid-19 deaths.

```
Call:
glm(formula = Death ~ `Age- Years (Visit) Old` + Sex + Nationality,
    family = binomial(), data = All_Deaths_2018_2020_Cleaned)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.5819  -0.3328  -0.2797  -0.2223   3.0419

Coefficients:
                          Estimate Std. Error z value Pr(>|z|)
(Intercept)              -5.460670   0.308367 -17.708  < 2e-16 ***
`Age- Years (Visit) Old`  0.022160   0.003054   7.257 3.95e-13 ***
SexMale                   0.821883   0.166573   4.934 8.05e-07 ***
SexUnknown               -9.611231 252.710209  -0.038 0.969662
NationalityNon-Citizen    0.577430   0.166486   3.468 0.000524 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 2465.6  on 7085  degrees of freedom
Residual deviance: 2381.9  on 7081  degrees of freedom
AIC: 2391.9

Number of Fisher Scoring iterations: 13
```

In this logistic regression model, the coefficient for Age is 0.022160, with a standard error of 0.003054 and a corresponding z-value of 7.257. This implies that, holding all other predictor

variables constant, the log chances of mortality rise by 0.022160 for every one-unit increase in age This effect is statistically significant because the p-value for this predictor variable is less than the threshold 0.05.

With a z-value of 4.934 and a standard error of 0.166573, the coefficient for Sex (Male) is 0.821883, this implies that males have larger log probabilities of death than females, all other predictor variables being held constant. This effect is statistically significant because the p-value for this predictor variable is less than 0.05.

The z-value for Nationality (Non-Citizen) is 3.468, the standard error is 0.166486, and the coefficient is 0.577430. According to this, non-citizens have higher log probabilities of death than citizens, all other predictor variables being held constant. This effect is statistically significant because the p-value for this predictor variable is less than 0.05.

It is worth noting that the coefficient for Sex (Unknown) is not a significant predictor of death, as its large standard error and high p-value suggest that it may not have a meaningful relationship with the outcome variable.

In summary, the results of this logistic regression model indicate that age, sex, and nationality are significant predictors of the likelihood of mortality, and that men and non-citizens may have a larger risk of death than their counterparts.

Research question 4: Is there a significant change in visits rate of Inpatient, Outpatient and Accident & Emergency during 2020 compared with 2018-2019?

To answer this question, by using R programming language, the changing rate was calculated. The results show that the number of inpatient visits in 2020 decreased by approximately 58.27% compared to the combined number of inpatient visits in 2018 and 2019. Similarly, the Outpatient department changing rate shows a value of -0.6591829, indicating a decrease of approximately 65.92% in outpatient visits in 2020 compared to the combined number of outpatient visits in 2018 and 2019. The changing rate in Accident and Emergency shows a value of -0.6313952, indicating

a decrease of approximately 63.14% in AE visits in 2020 compared to the combined number of Accident and Emergency visits in 2018 and 2019.

Category	Change_Rate
<chr>	<dbl>
Change_Inpatient	-0.5826923
Change_Outpatient	-0.6591829
Change_AE	-0.6313952

Independent samples t-tests were conducted to compare the mean number of patient admissions for three departments (Inpatient, Outpatient, and Accident & Emergency) between the pandemic period (Mar 2020-Dec 2020) and the pre-pandemic period (Jan 2018-Feb 2020). The results showed that there was a significant difference in the mean number of patient admissions for all three departments during the pandemic period compared to the pre-pandemic period, with p-values for all departments being less than the threshold of 0.05.

H_0 -Null hypothesis–- there is no significant difference in admission to the hospital departments between (Mar 2020- Dec2020) and (Jan 2018 to Dec 2020).

H_A- Alternative hypothesis–- there is significant difference in admission to the hospital departments between (Mar 2020- Dec2020) and (Jan 2018 to Dec 2020).

In order to test this hypotheses Welch Two Sample t-test is performed, the results are as follows:

The t-test resulted in a statistically significant result for inpatient admissions (t = 7.403, df = 12.694, p = 5.946e-06), providing strong evidence that there is no difference between the two time periods in terms of inpatient admissions.

The t-test also produced a statistically significant result for outpatient admissions (t = 5.5511, df = 11.796, p = 0.0001337), supporting the null hypothesis for this department as well. The t-test also produced a statistically significant result for admissions to Accident & Emergency departments (t = 8.1624, df = 11.554, p = 3.923e-06), supporting the null hypothesis for this department.

Overall, these results suggest that there was a significant difference in the number of patients admitted to these departments during the pandemic compared to the pre-pandemic period, with all p-values being less than the significance level of 0.05.

T-test for Inpatient Department:

```
        Welch Two Sample t-test

data:  Number_of_Inpatients_2018_2020$`2018-Feb2020` and
Number_of_Inpatients_2018_2020$`Mar-Dec2020`
t = 7.403, df = 12.694, p-value = 5.946e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  980.8629 1792.0448
sample estimates:
mean of x mean of y
 7002.654  5616.200
```

T-test for Accident & Emergency Department:

```
        Welch Two Sample t-test

data:  Number_of_AE_visits_2018_2020$`2018-Feb2020` and
Number_of_AE_visits_2018_2020$`Mar-Dec2020`
t = 8.1624, df = 11.554, p-value = 3.923e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 17122.66 29665.76
sample estimates:
mean of x mean of y
 57853.81  34459.60
```

T-test for Outpatient Department:

```
        Welch Two Sample t-test

data:  Number_of_OPD_visits_2018_2020$`2018-Feb2020` and
Number_of_OPD_visits_2018_2020$`Mar-Dec2020`
t = 5.5511, df = 11.796, p-value = 0.0001337
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 21049.11 48334.37
sample estimates:
mean of x mean of y
 104880.5   70188.8
```

Research question 5: How to determine the relationship between number of deaths and patients visits to the hospital three departments (Inpatient, Outpatient, and Accident and emergency?

This will be proved by digging deeper into the data of the three departments (Inpatient, outpatients, AE) and find if they had an impact on the numbers of non-Covid deaths. A multiple linear regression technique will be used for this purpose.

H_0 -Null hypothesis–- Hospital departments (Inpatient, Outpatient and Accident & Emergency) have no association with non-Covid-19 deaths.
H_A - Alternative hypothesis - Hospital departments (Inpatient, Outpatient and Accident & Emergency) have an association with non-Covid-19 deaths.

In order to test this hypothesis, Multiple Linear Regression analysis in R is performed, where the dependent variable is the monthly number of deaths, and the independent variables are the monthly number of inpatients, outpatients, and Accident & Emergency (AE) patients.

The OPD coefficient is -0.00123, which indicates that, when all other factors are held constant, a monthly drop in OPD patients is associated with an increase in monthly deaths of 0.00123 on average. The p-value for this coefficient is 0.00392, making it statistically significant.

The coefficient for AE is -0.00159, which indicates that, when all other factors are held constant, a monthly decline of one AE patient is associated with a monthly increase in deaths of 0.00159 on average. With a p-value of 0.03329, this coefficient is also statistically significant.

The coefficient for Inpatient is 0.001967, which suggests that an increase of one patient in inpatient department is associated with an average increase of 0.01967 deaths per month, holding other variables constant. This coefficient is statistically non-significant with a p-value of 0.14255.

Therefore, based on the statistical analysis, it cannot be concluded that there is a statistically significant relationship between the number of inpatients and the number of deaths during covid-19 pandemic, The lack of statistical significance for the coefficient of "Inpatient" could be due to the admission of COVID-19 cases during Covid-19 pandemic, which may have impacted the overall relationship between inpatient visits and non-COVID-19 deaths.

The adjusted R-squared value is 0.6027, which means that approximately 60% of the variation in the dependent variable (Non-Covid-19 Deaths) is explained by the independent variables (Inpatients, OPD and AE patients).

The F-statistic is 18.7 with a very small p-value of 3.441e-07, which suggests that the model as a whole is statistically significant in predicting the number of monthly deaths.

In summary, the results suggest that the number of monthly deaths is negatively associated with the number of monthly OPD and AE patients, but there is no significant relationship between monthly deaths and the number of Inpatients.

```
Call:
lm(formula = Deaths ~ Inpatients + OPD + AE, data = Inpatient_OPD_AE_2018_2020)

Residuals:
    Min      1Q  Median      3Q     Max
-48.177 -11.073  -0.939  12.200  52.169

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.573e+02  4.867e+01   5.286 8.65e-06 ***
Inpatients   1.967e-02  1.308e-02   1.503  0.14255
OPD         -1.230e-03  3.955e-04  -3.110  0.00392 **
AE          -1.590e-03  7.148e-04  -2.225  0.03329 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 23.63 on 32 degrees of freedom
Multiple R-squared:  0.6368,    Adjusted R-squared:  0.6027
F-statistic:  18.7 on 3 and 32 DF,  p-value: 3.441e-07
```

Overall, the findings imply that the pandemic significantly affected Non-Covid-19 deaths and that age, sex (for males category), and nationality (for Non-Citizens category) were significant predictors of mortality. According to the analysis, there was a significant difference in the number of patients admitted to inpatient, outpatient, and Accident & Emergency (AE) departments during the pandemic compared to the pre-pandemic period. Additionally, the analysis showed that the monthly numbers of outpatients and AE patients were significant predictors of the monthly number of deaths.

3.7 Key Findings from data analysis

In this step, the results of the analysis are put into action. This stage involves integrating the results of the analysis into the decision-making process and using them as the basis for strategic or operational decisions. In the case of a regression analysis of deaths, the deployment stage will involve the following steps:

The key finding from the analysis is as follows:

1. The study revealed that the non-Covid-19 death rate per 100,000 population during 2020 compared with 2018-2019 increased by 32.1%. These results indicate that the observed number of deaths was about 32.1% higher than the expected number of deaths based on the historical data of the years 2018-2019. This suggests that there was an excess mortality rate in 2020, which could be due to various factors such as COVID-19 and related disruptions to healthcare and daily life.
2. Welch Two Sample t-test was conducted to test the significant difference in non-Covid-19 mortality rate between 2020 and 2018-2019. The results revealed a significant increase in non-Covid-19 deaths during the pandemic (March 2020–- December 2020) compared to previous years (January 2018 to February 2020).
3. Logistic Regression analysis was conducted to determine the relationship between non-Covid-19 deaths and demographic features, such as nationality, gender, and age. The results indicated that age, sex, and nationality were important predictors of the likelihood of death, and that males and non-citizens may be at a higher risk for death than their counterparts.
4. The decrease in the number of visits to the inpatient, outpatient, and accident & emergency departments in 2020 compared to the combined number of visits in 2018 and 2019, with a decrease of approximately 58.27%, 65.92%, and 63.14%, respectively. This suggests that the COVID-19 pandemic had a significant impact on healthcare utilization patterns.

5. The analysis was conducted to determine if there was a significant change in the number of visits to the Inpatient, Outpatient, and Accident & Emergency (AE) departments during the pandemic compared to pre-pandemic times. Independent samples t-tests were conducted, which revealed a significant difference in the mean number of patient admissions for all three departments during the pandemic period compared to the pre-pandemic period, with p-values for all departments being less than the threshold of 0.05.

Further analysis was conducted to determine if the changes in patient visits were associated with non-COVID-19 deaths. Multiple linear regression was used to examine the relationship between the monthly number of non-COVID-19 deaths and the monthly number of inpatients, outpatients, and AE patients. The results showed that there was a significant negative association between the number of monthly non-COVID-19 deaths and the number of monthly OPD and AE patients, but there was no significant relationship between monthly deaths and the number of inpatients. This suggests that the decrease in patient visits to the OPD and AE departments during the pandemic may have been associated with an increase in non-COVID-19 deaths. lack of statistical significance for the coefficient of "Inpatient" could be due to the admission of COVID-19 cases during Covid-19 pandemic, which may have impacted the overall relationship between inpatient visits and non-COVID-19 deaths.

In summary, the results suggest that the pandemic had a significant impact on the number of patient visits to healthcare departments, with a significant decrease observed in all three departments. The adjusted R-squared value of 0.6027 indicates that approximately 60% of the variation in the monthly number of deaths can be explained by the Inpatients, Outpatients, and Accident & Emergency (AE) patients. The overall model is statistically significant in predicting the number of monthly deaths. However, the significant negative association was found between the monthly number of non-Covid deaths and only the monthly number of Outpatient (OPD) and Accident & Emergency (AE) patients, while there was no significant relationship between the monthly number of Non-covid-19 deaths and the monthly number of Inpatients.

CHAPTER 4

4.1 Conclusion

The purpose of this research is to investigate the potential impact of the Covid-19 pandemic on non-Covid-19 deaths in the United Arab Emirates. This study utilizes several datasets obtained from the Emirates Healthcare Services (EHS), including data from hospitals affiliated with EHS. It contained several important factors which are the demographic factors such as Age, Nationality, Sex, Date of Death, monthly number of deaths in each hospital department. These datasets helped to find out that there was a statistically significant increase in non-Covid-19 deaths in 2020 compared to the previous two years. Additionally, demographic factors such as age, sex, and nationality were found to be important predictors of the likelihood of death and that males and non-citizens may be at a higher risk for death than their counterparts. Furthermore, there was a significant difference in the number of patient admissions for all three departments (inpatient, outpatient, and Accident & Emergency) during the pandemic period compared to the pre-pandemic period, with all p-values being less than 0.05. The study revealed a significant negative correlation between the monthly number of non-Covid-19 deaths and the monthly number of outpatients (OPD) and accident & emergency (AE) patients. However, there was no significant relationship found between the monthly number of non-Covid-19 deaths and the monthly number of inpatients. This study has highlighted the significant impact of the Covid-19 pandemic on non-Covid-19 deaths in the UAE. The research findings underscore the importance of developing appropriate healthcare policies and guidelines that prioritize community health during pandemics.

4.2 Recommendation:

This information extracted from the analysis could be valuable for healthcare professionals and policymakers who are interested in understanding the effects of the pandemic on healthcare systems and planning for future healthcare crises. Based on these results, a recommendation could be as follow:

- Healthcare providers could also consider implementing measures to ensure the safety of patients and staff, such as strict infection control protocols and offering telemedicine options when appropriate. Also, communicate clear and consistent messaging about infection prevention measures, available healthcare services, and changes in healthcare delivery which can help alleviate patient concerns and reduce fear, anxiety, and confusion during a pandemic.
- The findings of this research paper indicate the need for policymakers and healthcare providers to pay close attention to the indirect effects of the Covid-19 pandemic on community health. To mitigate the risk of excessive non-Covid-19 deaths, it is recommended that healthcare facilities continue to provide essential services during the pandemic and implement measures to ensure patient'' safety from Covid-19 infection.
- Healthcare providers can prioritize high-risk patients, such as the elderly, those with chronic conditions, and immunocompromised individuals, for vaccination and other preventative measures to reduce their risk of contracting the virus.
- Efforts could be made to address the disparities in non-Covid-19 mortality rates observed among different demographic groups, such as males and non-citizens, by targeting interventions and resources towards these groups.
- Public health campaigns should be launched to address the public's fear of seeking healthcare services during the pandemic and increase awareness of the importance of regular medical check-ups, this will encourage individuals to continue seeking medical care, especially for urgent or emergency situations, despite the ongoing pandemic.
- Investigating the impact of COVID-19 on hospital admissions and inpatient care, including the effect on non-COVID-19 patients.

4.3 Future Work

- Further research could be conducted to explore the underlying reasons for the negative association between non-Covid-19 deaths and OPD and AE visits, and to determine effective strategies to mitigate the potential impact on patient outcomes.

- Further research is needed to assess the long-term effects of the pandemic on non-Covid-19 deaths and to identify effective strategies for mitigating the impact of pandemics on community health.
- Research can be conducted to investigate the causes of death during the pandemic COVID-19, this research can provide valuable insights into the impact of the pandemic on mortality rates and understanding the factors that is related to the excessive deaths which can help public health interventions and policy decisions to mitigate the impact of future pandemic on populations.
- Investigate whether infection control measures were sufficient to prevent further deaths related to respiratory infections.
- Investigating the impact of COVID-19 on hospital admissions and inpatient care, including the effect on non-COVID-19 patients.

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Appendix 1
Emirates Healthcare Services (ESH) & Ministry of Health Forms to obtain the required data for the research:

EHS/DSD/Form/015

Page 1

Dear Research Team,
Is this your first research proposal submission for Ethical Committee review/ Administrative approval?

☐ Yes ☐ No

If yes, the following remarks to be pope-up,
(In order to submit a good research proposal, you may go to Maharati platform for having a basic course on Research Proposal Writing, via https://maharati.ehs.gov.ae/login/index.php)

Page 2

Research Area

☐ Medicine ☐ Dentistry ☐ Nursing ☐ Physiotherapy

☐ Pharmacy ☐ Allied health sciences ☐ Other health profession disciplines

Page 3

Research Type

☐ Clinical Trail ☐ other

If other, navigate to **Page 4** to choose the suitable "Research Design" from the drop down.

TEMPLATE FOR SUBMISSION OF RESEARCH PROPOSAL

Research Design	☐ Case Report ☐ Case Series ☐ Descriptive Cross-sectional study ☐ Correlational study (/Ecological Study) ☐ Analytical Cross-sectional study (observational) ☐ Case control Study (Observational) ☐ Cohort Study (observational) ☐ Experimental studies – Non-Randomized (Quasi Experimental/community trails)

EHS/DSD/Form/015

	☐ Pilot Study ☐ Qualitative study ☐ Other If Other, Specify.....			
Research title				
Is application submitted for funding elsewhere?	Yes ☐ No ☐ If yes, Status: (please attach the submitted application & proof of outcome)			
Ethical Approval (From institutional IRB / other relevant Ethics committees)	Approval Date:			
	Authorization Body: (IRB, IEC/REC)			
	Reference Number:			
	(Note: The researcher cannot start the project before ethical approval has been granted from the concerned authority)			
Does the study involve human/animal samples	Yes ☐ No ☐			

Signature of Department/College Head: **Date of Approval:**

I. Principle Investigator Details

Full Name	Qualification (PhD, PG, UG, etc)
Academic Title (Dr. / Prof. / Ms. /Mr.)	Designation
Department	Institution
EHS Bayanati No: (if applicable) Phone: E-mail:	Signature

II. Co-Investigator Details*

Full Name	Academic Title (Dr. /Prof. etc) with Position,	Institution name	Phone., email-ID	Role in the Project	Signature

*If PI is not an employee of EHS, at least one of the CoI should be from EHS. If any of EHS facilities are used in the research, there should have at least one CoI from the respective facilities.

(Format requirement for the document: Font-Times New Roman, Font size – 12, Line spacing – 1.5)

III. Abstract

Provide research summary in 300 words (include Introduction, Objective, Methods, Expected impact of the research)

EHS | مؤسسة الإمارات للخدمات الصحية Emirates Health Services

EHS/DSD/Form/015

IV. Proposal Details

Problem Statement	
Research Question	
Objectives	**Primary Objective:** **Secondary Objectives: (optional)**
Hypothesis (any one of the hypotheses, null or alternative)	
Potential significance to EHS /UAE	
Operational definitions (if any, operational on the independent and outcome variables included in the study)	**Term/variable** | **Definition/operationalization**

Literature Review Provide background to the study, include information from preliminary studies which relevant to the current project, introduce the larger area of your research topic and relate to the current project, refine the content until reaching the specific domain of interest, add relevance to local community. Cite relevant references in the text numerically. (no more than 3000 words)

Research Methods Provide details of methods and materials used in the study in the below fields. Detail the proposed procedures/approaches and methodology applied in the study to solve your research problem to convince the reviewers that your potential solution is likely to be successful. References shall be cited if needed.	
Methods in specific: fill the following fields	
Research Design and methodology	
Population	
Inclusion & Exclusion criteria	
Explain the study instrument used if any and its validation procedure (questionnaire/ interview forms, Lab records if any. Mention lab instruments/equipment if applicable)	
Sample Size (explain the scientific calculation of sample size if it's a sample-based study)	
Sampling technique (if it's a sample-based study)	
Study setting (the physical/experimental context in which the study being conducted)	
Study period (month/year)	
Brief ethical approach involved in the study (process of taking participant consent, Indicate proposed strategies to minimise any potential risks to subjects, procedures followed to maintain the anonymity and confidentiality of the subjects, other ethical concerns if any)	
Data availability and Storage (Brief on data availability, statement on data storage, data entry and confidentiality)	
Analytical Methods (brief on statistical methods, software/tools available for analysis)	
Expected impact of the research	

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Time line of the Research *(add step-by-step description of Project progress; please add rows or revise the activity list if needed)*

List of Research Activities	Year -----			
	Q1	Q2	Q3	Q4
Literature Review				
Planning and Designing of Research				
Finalization of Research Proposal & Approval process				
Data collection				
Data Entry/Data compilation				
Analysis				
Interpretation and Report Writing				

References

Provide all the citation either in Vancouver or Harvard refencing style.

(include authors upto 3, full title of publication, journal title, year of publication, volume (issue) and page number. Pls refer the materials *Link1 - Harvard, Link2-Vancouver)*

Example for Vancouver referencing of journal article: Thiese MS, Arnold ZC, Walker SD, et al. The misuse and abuse of statistics in biomedical research. Biochem Med. 2015;25(1):5-11.
Example for Harvard referencing of journal article: Conley, TG & Galeson, DW 1998, 'Nativity and wealth in mid-nineteenth century cities', Journal of Economic History, vol. 58, no. 2, pp. 468-493.

V. Collaborative support

☐ Yes ☐ No

If Yes, details of Institutes collaborated for the Research

Details of any support provided by the collaborative unit in terms of sharing support services, facilities, equipment, infrastructure, technical or other assistance

Organization	Department	Role or support granted	Signature

VI. Budget Details

☐ Yes ☐ No

EHS/DSD/Form/version.1 2022

If Yes, please provide the budget details in the following table				
Category	**Item** (equipment/chemicals/stationary/research assistants/publication cost/other etc)	**Quantity**	**Unit Price**	**Total Cost**
Product				
Personnel				
Other				
Total				

VII. Documents to be enclosed

1. Questionnaire (if applicable)
2. Consent form (if applicable)
3. Evidence document of budget Approval (if applicable)
4. Curriculum Vitae of the Investigator(s)
5. Documents related to funding applied/received (if applicable)
6. REC Approval Letter (if applicable)

DSD Approval Status:

☐ Approved ☐ Needs Revision

For Research office use only

Proposal No: Date of Receipt:

DSD review Date: Date of sending reviewer comments to the Investigator:

DSD approval Date (ethics committee approval):

Waiver of Consent Form

Principal Investigator

Name	
Title	
Institutional affiliation	
Email Address	
Phone Number	
Signature	

Project Information

Title	
Abstract Max 250 words	
What is the principal goal of the project?	
Where will participants be identified?	•

Reason for requested EXEMPTION

	YES	NO
Is this the topic of hypothesis based research?		
Will electronic medical records be examined for this project?		
Is this a case report or series less than 5?		
Is this a student exercise, unlikely to be published?		
Reasons for exemption:		

Is the purpose quality improvement?	X	
Other reasons for EXEMPTION		
How will the participants be included in the study?		

Protected Health Information

What patient identifiers will be recorded? How will PHI be stored and safeguarded?	

Approval of an EXEMPTION does not remove the obligation of the Applicant to protect PHI and other aspects of subject privacy.

UNITED ARAB EMIRATES
MINISTRY OF HEALTH

الإمارات العربية المتحدة
وزارة الصحة

RESEARCH ETHICS COMMITTEE

APPLICATION FOR SCIENTIFIC AND ETHICAL APPROVAL OF RESEARCH PROJECT

INSTRUCTIONS

IMPORTANT

- **This form has been created to help Junior researchers**
- **The senior researchers have to submit their study protocol with all the needed Information (Sections--------) as text form in the provided blank pages at the end of this application and to submit one (1) original and 8 copy with a CD copy of all Research documents to the Office of the statistics and Research Ethics Committee.**

Instructions to fill the application form

a) **The application must be clearly legible**
b) **Typing or block capitals are recommended**
c) **All sections of the application form must be completed**
d) **Write "Not Applicable" wherever appropriate**
e) **A Free text can be written on the given blank pages**
f) **The appropriate pages for signatures are Mandatory should be printed –signed & scanned**

1)PROJECT TITLE

Full Title

Short Title (100 characters)

2)NATURE OF STUDY (Place X in the column)

Faculty Research University	☐	Graduate Research ☐	Undergraduate Research ☐
Dissertation	Master ☐	Staff Research ☐	
	Master MPhil ☐		
	PhD ☐	Others: ☐ ----------	

3)TYPE OF THE PROJECT (Tick more than one option if applicable)

☐ Drug Study ☐ Device Study (attach device form) ☐ Chart/Records Review ☐ Basic Research

☐ Biomedical Research ☐ Diagnostic Research ☐ Community-Based ☐ Qualitative Research

☐ Social and Behavior Research ☐ Therapeutic Research ☐ Others: ----------

4)PRINCIPAL INVESTIGATOR

Title/Name :

Position : Institution:

Unit/Department:

Contact No office : Mobile: Fax: Email Address:

Note: Students cannot be principal investigators on a study

5)CO-INVESTIGATOR (S)

Title	Name	Position	Staff No	Email	Contact No	Unit & Department	Institute	Emirates ID

Principal Investigator Signature _____ Date _____

Your signature indicates that you have reviewed ,approved the proposal and you have agreed to be responsible for the ethical and scientific aspects of the project

6)CONTACT PERSON –REACHABLE 24 HOURS

Title/Name:

Tel. Office:

Fax :

Mobile :

Email address :

Emergency no:

7)QUALIFICATIONS OF ALL THE INVESTIGATORS WITH EXPERIENCE ON THE RESEARCH

1) To provide all copies of their Certificates

2) To provide C.V

8) DOES THE INVESTIGATOR OR KEY PERSONNEL HAVE ANY CONFLICT OF INTEREST IN THIS STUDY?

☐ Yes ☐ No

If yes, please explain:

9) HAS THIS RESEARCH PROPOSALS BEEN APPROVED BY INSTITUTIONAL REVIEW BOARD (IRB) OR RESEARCH ETHICS COMMITTEE ELSEWHERE?

☐ Yes ☐ No

If 'Yes', please provide the following information: (Please attach a copy)

a. Name of institution that reviewed this research proposal

b. Address of reviewing institution

I. Name of the Institute

II. Telephone No

III. Email address

10) HAS THIS STUDY BEEN DONE ELSEWHERE IN U.A.E?

☐ Yes ☐ No

If 'Yes', how does this differ from the ones done earlier.

11) STARTING DATE OF THE PROPOSED STUDY	PROPOSED DATE OF COMPLETION	APPROXIMATE MONTHS

12) THE LOCATION (S) WITHIN THE UAE WHERE THE RESEARCH IS TO BE CONDUCTED

1.		6.	
2.		7.	
3.		8.	
4.		9.	
5.			
6.		10.	

13) WILL THE RESEARCH BE IN A MULTI CENTER RESEARCH OR STUDY?

☐ Yes ☐ No

If yes, which are the other centers involved?

14) WILL THE RESEARCH /STUDY INVOLVE HUMAN SUBJECTS?

☐ Yes ☐ No

If 'Yes', will you have direct contact or intervention with them?
(e.g., as subject's physician; in obtaining samples directly from the subject; by interviewing the subject?)

☐ Yes ☐ No

15] WHAT ARE THE GOALS OF THE RESEARCH?

Summarize the background and hypothesis of the study.

a) What is the primary objective of the study?

b) Secondary objectives of the study what is the beginning to be consistent?

c) Why is this research important? What contributions will it make? To knowledge and evidence

d) How can this study be useful to the participating institutions and to the UAE?

Appendix 2

R Programming Language Codes:

```r
```{r car}
##1
library(readxl)
Deaths_Disrtipution <- read_excel("8_-_Distribution_of_Deaths_by_Cause,_Sex,Nationality_&_Age_Group (3) - Copy.xlsx")

# convert the "numbers" column to character
Deaths_Disrtipution$`Encounter Id` <- as.character(Deaths_Disrtipution$`Encounter Id`)

summary(X8_Distribution_of_Deaths_by_Cause_Sex_Nationality_Age_Group_3_Copy)

library(ggpubr)
library(DataExplorer)


plot_missing(Deaths_Disrtipution)
library(dplyr)
library(tidyr)
library(imputeTS)
Deaths_Disrtipution <- read_excel("8_-_Distribution_of_Deaths_by_Cause,_Sex,Nationality_&_Age_Group (3) - Copy.xlsx")

###Remove unncessary columns:
# select columns "a" and "c"
df_new <- Deaths_Disrtipution[, c("Patient Code", "Nationality", "Sex", "Age- Years (Visit) Old", "Discharge Date & Time", "Building")]
view(df_new)

###Replace the missing value:
df_new$`Age- Years (Visit) Old`<- na_mean(df_new$`Age- Years (Visit) Old`)

plot_missing(df_new)



```
```

```r cars
### Test the hypothese for difference in admission to the hospital before and during the pandemic.

library(readxl)
Number_of_Inpatients_2018_2020 <- read_excel("New folder/Number of Inpatients 2018-2020.xlsx")


# Conduct the Welch's t-test
t_test_result <- t.test(Number_of_Inpatients_2018_2020$`2018-Feb2020`,
Number_of_Inpatients_2018_2020$`Mar-Dec2020`, var.equal = FALSE)

# Print the test result
print(t_test_result)


```

```r cars
### Test the hypothese for difference in Accident & Emergency visits to the hospital before and during the
pandemic.

# Load the data
library(readxl)
Number_of_AE_visits_2018_2020 <- read_excel("New folder/Number of AE visits 2018-2020.xlsx")

# Conduct the Welch's t-test
t_test_result <- t.test(Number_of_AE_visits_2018_2020$`2018-Feb2020`,
Number_of_AE_visits_2018_2020$`Mar-Dec2020`, var.equal = FALSE)

# Print the test result
print(t_test_result)


```

```r cars
### Test the hypothese for difference in Outpatients visits to the hospital before and during the pandemic.

# Load the data
library(readxl)
Number_of_OPD_visits_2018_2020 <- read_excel("New folder/Number of OPD visits 2018-2020.xlsx")


# Conduct the Welch's t-test
t_test_result <- t.test(Number_of_OPD_visits_2018_2020$`2018-Feb2020`,
Number_of_OPD_visits_2018_2020$`Mar-Dec2020`, var.equal = FALSE)

# Print the test result
print(t_test_result)


```
```r cars

# Non-Covid-19 Deaths (T-test to check the difference between (Jan 2018-Feb 2020) and (Mar 2020 - Dec 2020))

### T-test for the whole year of 2020:

# Load the data
library(readxl)
Count_of_Deaths_from_Jan_2018_Dec2020 <- read_excel("New folder/Count of Deaths from Jan 2018-Dec2020.xlsx")


# Conduct the Welch's t-test
t_test_result <- t.test(Count_of_Deaths_from_Jan_2018_Dec2020$`Deaths from Jan 2018-Feb2020`,
Count_of_Deaths_from_Jan_2018_Dec2020$`Deaths from Mar-Dec 2020`, var.equal = FALSE)

# Print the test result
print(t_test_result)


```

```r car}

# Load the data
library(readxl)
Count_of_Deaths_from_Jan_2018_Dec2020 <- read_excel("New folder/Count of Deaths from Jan 2018-Dec2020.xlsx")


# Calculate mean of first column (Jan 2018-Feb 2020)
mean1 <- mean(Count_of_Deaths_from_Jan_2018_Dec2020$`Deaths from Jan 2018-Feb2020`)

# Calculate mean of second column (Mar 2020-Dec 2020)
mean2 <- mean(c(182,256,335,259,224,193,195,176,240,227))

print(mean1)
print(mean2)

# Calculate mean difference as a percentage of difference
percent_diff <- ((mean2 - mean1) / mean1) * 100

# Print the result
print(paste("The mean difference as a percentage of difference is:", percent_diff, "%"))




```

```r

library(readxl)
library(tibble)

# Load the data from Excel file
Deaths_Rate <- read_excel("Deaths Rate.xlsx")

# Calculate the yearly death rate per 1000 patient visits
Deaths_Rate$Yearly_Death_Rate <- (Deaths_Rate$`Number of Non-Covid-19 Deaths` / Deaths_Rate$population) * 100000

# Group the data by year and calculate the mean yearly death rate
Yearly_Deaths_Rate <- aggregate(Yearly_Death_Rate ~ Year,
                                data = Deaths_Rate,
                                FUN = mean)

# Print the result
Yearly_Deaths_Rate

# Calculate the percentage change between 2018-2019 and 2020
change <- ((Yearly_Deaths_Rate$Yearly_Death_Rate[3] - mean(Yearly_Deaths_Rate$Yearly_Death_Rate[1:2])) /
mean(Yearly_Deaths_Rate$Yearly_Death_Rate[1:2])) * 100

# Print the result
cat("The percentage change in yearly death rate between 2018-2019 and 2020 is:", round(change, 2), "%")

```

```r car}

library(forecast)
library(ggplot2)
library(readxl)
# read in the data
deaths <- read_excel("New folder/Count of Non-Covid-19 Deaths 2018-2020.xlsx")

# calculate the expected deaths based on historical data (2018-2019)
avg_deaths <- mean(deaths$`Deaths from Jan 2018-2020`[1:26])
expected_deaths <- avg_deaths * 10 # assuming a year-long time period

# calculate the P-score for the year 2020
observed_deaths <- sum(deaths$`Deaths from Jan 2018-2020`[27:36])
p_score <- observed_deaths / expected_deaths

# print the results
cat("Expected deaths:", expected_deaths, "\n")
cat("Observed deaths:", observed_deaths, "\n")
cat("P-score:", p_score)

```

```r car}
### calculate the change rate of admission in the three hospital departments
# Load required packages
library(dplyr)
library(readxl)

# Read in data
Hospital_Rate <- read_excel("Hospital department changing rate 2018-2020.xlsx")

# Group the data by year and calculate the total patient visits for each year
visits_by_year <- Hospital_Rate %>%
  group_by(Year) %>%
  summarise(Total_Inpatient = sum(Inpatient),
            Total_Outpatient = sum(Outpatient),
            Total_AE = sum(AE))

# Calculate the change rate for each column between 2018-2019 and 2020
change_rates <- visits_by_year %>%
  summarise(
    Change_Inpatient = (Total_Inpatient[Year == "2020"] / sum(Total_Inpatient[Year %in% c("2018", "2019")])) - 1,
    Change_Outpatient = (Total_Outpatient[Year == "2020"] / sum(Total_Outpatient[Year %in% c("2018", "2019")])) -
1,
    Change_AE = (Total_AE[Year == "2020"] / sum(Total_AE[Year %in% c("2018", "2019")])) - 1
  )

# Combine the change rates into a single column
change_rates_long <- change_rates %>%
  pivot_longer(cols = starts_with("Change_"), names_to = "Category", values_to = "Change_Rate")

# Print the result
change_rates_long

```

```r car}
###& Logistic Regression to find the variables that correlated to the deaths
# Load required packages
library(readxl)
library(dplyr)
library(tidyr)
library(glmnet)
library(caret)

# Read in data
All_Deaths_2018_2020_Cleaned <- read_excel("New folder/All Deaths 2018-2020- Cleaned.xlsx")

# Rename dependent variable column
colnames(All_Deaths_2018_2020_Cleaned)[colnames(All_Deaths_2018_2020_Cleaned) == "death covid-noncovid"] <- "Death"

# Convert Death column to a factor
All_Deaths_2018_2020_Cleaned$Death <- as.factor(All_Deaths_2018_2020_Cleaned$Death)


# Run logistic regression on training data
model <- glm(Death ~ `Age- Years (Visit) Old` + Sex + Nationality, data = All_Deaths_2018_2020_Cleaned, family = binomial())

# Calculate odds ratios and confidence intervals
summary(model)

```

```r car}

library(readxl)
Inpatient_OPD_AE_2018_2020 <- read_excel("New folder/Inpatient-OPD-AE 2018-2020.xlsx")


model <- lm(Deaths ~ Inpatients + OPD + AE, data = Inpatient_OPD_AE_2018_2020)
summary(model)


```

```r
library(readxl)
Patients_visits <- read_excel("New folder/Inpatient-OPD-AE 2018-2020 - Copy.xlsx")
Patients_visits$Months <- factor(Patients_visits$Months)
summary(Patients_visits)
sd(Patients_visits$Inpatients)
sd(Patients_visits$OPD)
sd(Patients_visits$AE)
# Load the required packages
library(ggplot2)
library(cowplot)
# Create three separate boxplots for each variable
p1 <- ggplot(Patients_visits, aes(x = "Inpatients", y = Inpatients)) +
  geom_boxplot() +
  labs(x = NULL, y = "Inpatients") +
  theme(text = element_text(size = 16))
p2 <- ggplot(Patients_visits, aes(x = "OPD", y = OPD)) +
  geom_boxplot() +
  labs(x = NULL, y = "OPD") +
  theme(text = element_text(size = 16))
p3 <- ggplot(Patients_visits, aes(x = "AE", y = AE)) +
  geom_boxplot() +
  labs(x = NULL, y = "AE") +
  theme(text = element_text(size = 16))
# Add outliers to the plots
outliers_Inpatients <- boxplot.stats(Patients_visits$Inpatients)$out
outliers_OPD <- boxplot.stats(Patients_visits$OPD)$out
outliers_AE <- boxplot.stats(Patients_visits$AE)$out
if (length(outliers_Inpatients) > 0) {
  p1 <- p1 + geom_point(data = data.frame(x = "Inpatients", y = outliers_Inpatients),
                        aes(x = x, y = y))
}
if (length(outliers_OPD) > 0) {
  p2 <- p2 + geom_point(data = data.frame(x = "OPD", y = outliers_OPD),
                        aes(x = x, y = y))
}
if (length(outliers_AE) > 0) {
  p3 <- p3 + geom_point(data = data.frame(x = "AE", y = outliers_AE),
                        aes(x = x, y = y))
}
```

```r
# Combine the three plots using cowplot's plot_grid() function
plot_grid(p1, p2, p3, ncol = 3, align = "h", labels = c("A", "B", "C"))
# Add overall plot title
ggdraw() +
  draw_label("Boxplots for Inpatients, OPD, and AE", fontface = "bold", x = 0.5, y = 0.98, size = 18)
```