Menemui Matematik
(Discovering Mathematics)

journal homepage: https://myjms.mohe.gov.my/index.php/dismath/

Investigating The Malaysian Mortality Rate During COVID-19

Ahmad Ashraful 'Ilmi Bin Razak[1] and Rose Irnawaty Ibrahim[2*]
[1, 2]Faculty of Science and Technology, Universiti Sains Islam Malaysia, Malaysia
Bandar Baharu Nilai, 71800 Nilai, Negeri Sembilan Malaysia

[1]a_capes@raudah.usim.edu.my, [2*]rose.irnawaty@usim.edu.my
*Corresponding author

Received:13 Januari 2024
Accepted:20 August 2024

ABSTRACT
COVID-19 undeniably caused a pandemic and in turn, affected the entire world. Malaysia is not an exception when it comes to deaths and mortalities related to the pandemic. This study aims to find the estimates for Malaysia's mortality trend of each gender, age group and state in Malaysia, as well as determine the top health backgrounds or comorbidities that contributed to the COVID-19 mortality. With that, this study also aims to analyse the trend of these mortality rates graphs. Using the conditional probability, survival functions and conditional mortality formula, this study found that COVID-19-attributed deaths are higher in males than females, the elderly group than the middle-aged, adults and children's groups. This study also found that the death numbers are higher in Selangor and Sabah; whilst hypertension and diabetes are found to be the two most common comorbidities of COVID-19 in Malaysia.

Keywords: Comorbidities, COVID-19, Gender, Mortality Rates, States

INTRODUCTION

The COVID-19 epidemic, caused by the severe acute respiratory syndrome Coronavirus-2, SARS-CoV-2, went through two stages. The former was a local epidemic that began in December 2019 in China, and the latter was the virus's subsequent spread (Petti & Cowling, 2020). The World Health Organization (WHO) classified the COVID-19 outbreak as a pandemic on March 11, 2020 (World Health Organization (WHO), 2020). In a little more than a year, COVID-19 has become the biggest health catastrophe of the twenty-first century. Through December 23, 2020, COVID-19 will be blamed for around 78 million infections and 1.7 million deaths worldwide, or 2.9% of all new fatalities. The COVID-19 outbreak and the fatalities it has caused have spread unevenly between and within countries. With 18.6 million infected people and 3,30,824 deaths attributable to COVID-19, the United States is responsible for 23.8% of global infections and 19.2% of global mortality (Vasishtha et al., 2021).

Malaysia's Ministry of Health discovered COVID-19 for the first time on January 25, 2020, among three Chinese individuals who entered the country through Singapore on January 23, 2020. On January 30, 2020, there were eight verified COVID-19 instances, all of which involved Chinese people. Malaysia's Ministry of Health discovered the first local COVID-19 infection on February 4, 2020, before the number of infected people stayed under twenty-five until March 1, when the number of infected people jumped to twenty-nine. The overall number of COVID-19 cases gradually climbed before spiking on March 14. The first two COVID-19-related deaths were recorded on March 17, following which the number of cases of death progressively grew, but it remained below one hundred until April 29 (See et al., 2020).

The exact fatality rates in many nations continue to be understated due to the virus' asymptomatic nature and inadequate testing and monitoring systems. More studies on the breadth of the infection, associated risk factors, predicting fatalities and measuring the loss of life expectancy, premature mortality, and other actuarial variables are becoming available as the COVID-19 virus spreads across nations (Vasishtha et al., 2021). However, this study does not deny the fact that the mortality rate will naturally change every year. The mortality rate, which measures the frequency of deaths in a specific population over a certain period, has numerous estimates recorded for it. Vital statistics are frequently used to calculate the mortality rate. The denominator stands for the population size at the midpoint of the study period (Azizi, Esmaeili and Fakhari, 2020).

This study aims to delve into the depth of this pandemic's impacts on the nation's mortality rates. Specifically, this study targets to find the estimate for Malaysia's mortality rates for specific age group, gender, state, and health background. After finding the estimates, this study will also analyse the trend of the mortality rate in graphs respective to the demographic and health factors. This study is limited to the estimation of the mortality rate for the Malaysian population, as the study on this estimation is currently lacking for the Malaysian population. By analysing the mortality rate data trend in a graphical form, this study can further assess the information in an organized timeframe, with a background investigation of the causes of the changes in the trend. This study covered the timeframe within the first death after the declaration of COVID-19 as a pandemic and post-pandemic, specifically from March 23rd, 2020, until April 2021 as the data is unavailable afterwards. Nonetheless, this study investigated the mortality rate trend in every COVID-19 phase for all age groups, genders, and states, along with the discovery of the disease that has coexisted and contributed to these significant death numbers. Despite its simplicity and limits, this study still succeeded in achieving the objectives pertained in the beginning.

LITERATURE REVIEW

Mortality Rates Against Age Groups and Genders

A study by Aburto et al. (2022) that involved 29 countries in Europe, the United States and Chile reported that between 2019 and 2020, life expectancy decreased for both sexes in every nation, except for Finland for women and Denmark and Norway for both sexes. Male life expectancy losses were higher in 2020 than for females, except for Spain, Slovenia, Estonia, and Northern Ireland. Most increases in life expectancy made in the five years before the pandemic was mostly negated by the extent of these decreases. Males and females from 10 of the 29 nations had a shorter life expectancy at birth in 2020 compared to 2015, which was already an abnormally poor year for life expectancy due to an unpredictable severe flu season (Aburto et al., 2022).

Another study carried out by Goldstein and Lee (2020) stated that the impact of transient pandemic mortality is exaggerated by the fall in life expectancy. The standard approach to describe the mortality in a year is the "period" life expectancy at birth. Life expectancy at birth was 78.86 years in 2017, the most recent year for which comprehensive data were available for the United States. This figure assumes that people live their whole lives, from conception to death, under the mortality conditions of that year. However, because it implicitly presupposes that the epidemic is experienced year after year as a person ages, life expectancy at birth is a false statistic in the context of epidemic mortality. According to the reported average age trend of COVID-19 mortality, a million COVID-19 fatalities would result in a 2.94-year drop in life expectancy. Such a reduction would briefly return us to the mortality trends of 1995 when the average lifespan was 75.88 years, 2.98 years lower than it is today. The same computation would result in a 0.84-year drop in life expectancy if there were 250,000 COVID-19 deaths (Goldstein and Lee, 2020).

The same study has also found that the United States recorded an exponential growth of mortality rate in the increasing ages, as shown in the snipped Figure 1.

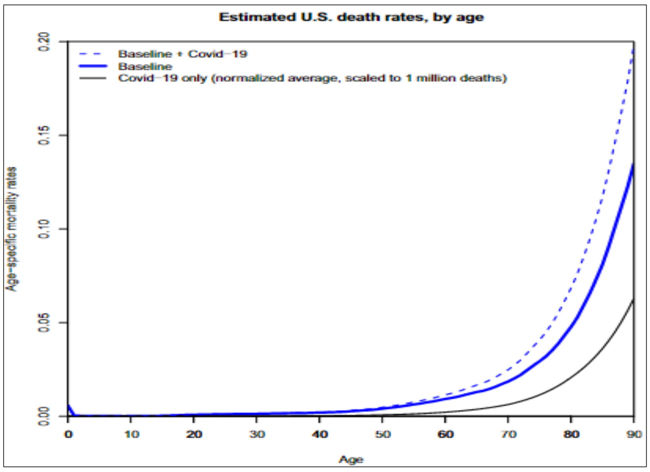

Figure 1. Estimated U.S. Death Rates, by Age

A study in India by Vasishta et al. (2021) noted that the virus has changed the death-by-age trend. This trend indicates that after the age of 44, the probability of dying with COVID-19 increases relative to the probability of dying without COVID-19. The risk of dying before the age of 44 was similar before and after the COVID-19 outbreak. When compared to those without COVID-19, persons between the ages of 45 and 75 have a greater risk of dying from COVID-19. Attached in Figure 2 is the snipped graph taken from the stated journal.

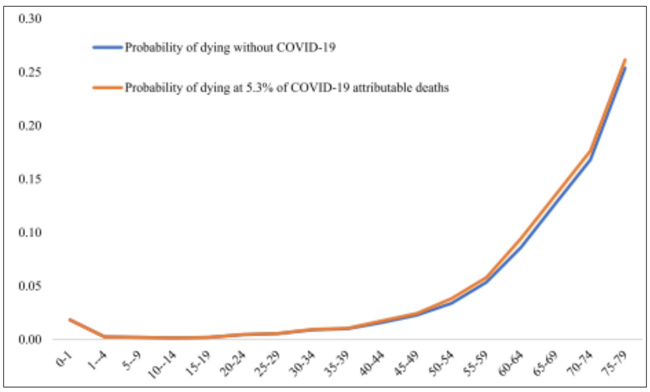

Figure 2. Probability of mortality in Maharashtra, India, with and without the 5.3% COVID-19 attributed deaths

The study also found that pre-COVID-19, the premature death rate was 0.34; after COVID-19, it jumped to 0.36. According to the existing mortality trend, premature mortality would rise to 0.37 and 0.38, respectively, if the percentage of deaths attributed to the illness reached 8 and 10%. Before COVID-19, the risk that a person of working age will die as a result of the current infection rate was 0.15; now, it is 0.16. The working-age group's mortality risk would increase to 0.17 under the 10% COVID-19 attributable death share scenario (Vasishtha et al., 2021).

Another study conducted in Europe found that in practically all age categories and localities, males were more likely than women to pass away from COVID-19. Portugal had a relative risk of 1.11 (95 per cent confidence interval, CI 1.01-1.23), while France had a relative risk of 1.54 (95 per cent CI 1.49-1.58). In most countries, sex differences widened between the ages of 60 and 69 and then declined, reaching their lowest point at 80 and beyond (Ahrenfeldt et al., 2020).

Studying COVID-19 mortality rates across age groups can help researchers and public health officials better understand the virus and the populations that are most at risk for severe illness and death. This information can inform decisions about how to allocate resources and develop public health interventions. It also helped to identify the priority group for the vaccine and other healthcare resources. Additionally, studying mortality rates across age groups can provide insights into possible underlying factors that contribute to susceptibilities to the virus, such as comorbidities or genetics. Studying COVID-19 mortality rates across gender can help researchers and public health officials understand if there are any differences in the way that men and women are affected by the virus. This information can inform decisions about how to allocate resources and develop public health interventions tailored to specific genders. There are several reasons why gender may be an important factor to consider when studying COVID-19 mortality. Furthermore, women have been found to have some protective mechanisms against the virus and have a better outcome than men in some cases. Studying these disparities in mortality rates across gender can help to identify potential risk factors for severe illness and death and could inform targeted public health interventions and resource allocation strategies to better protect the most vulnerable populations.

Mortality Rates Against States

A study in the United States of America (USA) by Anaele et.al in 2020 found that there has been a relationship between race and COVID-19 mortality rates, where the eastern part of the USA had higher COVID-19 death rates as of May 27, 2020, compared to the central and western regions, with the northeast having the highest rates. The COVID-19 mortality rates, the percentages of African Americans in the population increased from the west to the northeast. Except for Connecticut, Rhode Island, and Massachusetts, all north-eastern states with mortality rates in the highest group (53.58-149.55 fatalities per 100,000 people) also had the largest percentage of African American populations (22.12-46.94 per cent). African Americans made up 6.55 to 10.56 per cent of the population in these states (Anaele, Doran and McIntire, 2020).

The overall mortality rate related to COVID-19 in Europe has been much higher than in the United States (Petti and Cowling, 2020). According to the latest data, the European mortality rate has been estimated to be around 6.5%, which is more than three times the mortality rate of the United States (2%), albeit considerably lower than the global average (7.5%). When looking at the specific countries in Europe, there are some noticeable variations in their mortality rates. For instance, the UK has been one of the countries with the worst mortality rates in Europe, with more than 11% of all reported cases resulting in death. Moreover, the UK has seen the highest number of deaths due to COVID-19 in the entire continent. On the other hand, countries like Greece, Serbia and Sweden have been able to keep the mortality rate of COVID-19 at a very low level, at around 0.5% (Petti and Cowling, 2020).

It is important to note that a key factor in determining the mortality rate from COVID-19 is the quality of healthcare available in each country. Countries with superior healthcare systems have been able to keep the rate at a low level. It is worth mentioning that since the outbreak of the pandemic, European countries have adopted a range of measures, including containment and anti-contagion policies, which have had an important impact in containing the spread of the disease and keeping mortality rates in check (Blandford et al., 2022). Overall, the COVID-19 mortality rate in Europe has varied considerably between states, reflecting the differences in economic and healthcare systems present in different countries. However, it is important to note that putting in place effective measures to contain the disease, coupled with a well-equipped healthcare system, is the most effective way to curb the mortality rate of COVID-19.

A recent study, published in the Journal of Travel Medicine in April 2020, found that the COVID-19 case-fatality rate was higher in urban areas in China, with the highest rates being reported in Wuhan (the epicentre of the outbreak) and other large cities such as Beijing, Shanghai, and Guangzhou. Urban areas tend to have higher concentrations of people, making it easier for the virus to spread. In addition, many people in urban areas are likely to live in closer proximity, increasing the potential for person-to-person transmission. Furthermore, poorer access to healthcare in rural areas may exacerbate the effects of the virus, increasing mortality rates, possibly due to differences in healthcare access and underlying health conditions (Liu, Zhang and Li, 2020).

Mortality Rates and Their Comorbidities

Comorbidities, or the presence of multiple chronic medical conditions in an individual, have been identified as a major risk factor for severe illness and death from COVID-19. A review of data from multiple countries found that people with underlying health conditions such as diabetes, cardiovascular disease, and respiratory conditions had a higher risk of severe illness and death from COVID-19.

Vasishtha et al. (2021) did research on effect COVID-19's on premature mortality, life expectancy, years of potential life lost, and disability-adjusted life years in Maharashtra, one of the worst affected states in India. Provided that the total population in both Maharashtra and India are 123,961,000 and 1,355,417,000 respectively, the study shows that COVID-19 is accountable for 1.15% of total deaths (12, 694,688), which is a total of 145,845. The total number of fatalities in Maharashtra is 48,746; this represents 5.3% of all fatalities through December 20, 2020 (Vasishtha et al., 2021).

A study of data from the United States found that the presence of comorbidities was significantly associated with an increased risk of hospitalization and death from COVID-19 (Richardson, Hirsch and Narasimhan, 2020) Similarly, a study of data from China found that people with comorbidities had a higher risk of severe illness and death from COVID-19. The impact of comorbidities on COVID-19 mortality rates may be influenced by other factors such as age, gender, and access to healthcare (Yin, Li and Luo, 2021). A review of data from multiple countries found that the risk of death from COVID-19 was higher among older individuals and men and that people with underlying health conditions had a higher risk of severe illness and death from COVID-19 (Dessie and Temesgen, 2021).

High blood pressure, sometimes referred to as hypertension, is a significant risk factor for COVID-19-related severe illness and mortality. The most prevalent comorbidity among COVID-19 patients who passed away was hypertension, according to a study written up in the Journal of the American Medical Association (JAMA) (Yang, Hou and Shen, 2022). The study examined data from over 4,000 COVID-19 patients in Wuhan, China, and discovered that hypertension was present in 45.6% of the fatalities. Diabetes (30.9%), cardiovascular disease (24.6%), and chronic respiratory illness (19.3%) were other prevalent comorbidities. The chronic disease diabetes, on the other hand, alters how the body uses sugar and is a known risk factor for COVID-19-related severe illness and mortality. A study in the Journal of the American Medical Association claims that (JAMA), diabetes was the second most common comorbidity in COVID-19 patients who died.

METHODOLOGY

To fulfil the research objectives, this study aimed to obtain the deaths number or the mortality numbers of the Malaysians with respect to the age groups defined in the Malaysian Abridged Life Tables. These data are obtainable from (Ministry of Health Malaysia, 2022), where a mentioned link on the website displays various aspects of COVID-19 deaths. This study investigated the deaths by age groups, zones, genders, and respective health backgrounds for the time frame beginning from March 17th, 2020, the start of COVID-19 death in Malaysia until April 2021, as the data is unavailable afterwards (Kementerian Kesihatan Malaysia, 2021). To get a better view on how COVID-19 affected different age categories, the study categorized age groups 0 – 14 years old as “children”, age groups 15 – 39 years old as “adults”, age groups 40 – 59 years old as “middle-aged”, and age groups above 60 years old as “elderly”.

Estimating the Mortality Rates

To get the basis of the mortality rate idea, this study used basic notation, which is T_x, which is the remaining future lifetime of a person-aged x. For instance, the future lifetime for a new-born baby is notated as T_0.

This notation is accompanied by the statistical function $F_x(t)$, which explains the probability that a person aged x dies exactly no later than age t. By using the example earlier, when $x = 0, F_0(t) = Pb[T_0 \leq t]$. As this study notated $F_x(t)$ as a death probability, the survival probability became $S_x(t)$ which is $1 - F_x(t)$, and $S_0(t) = Pb[T_0 > t]$.To connect between $F_0(t)$ and $F_x(t)$, recall the definition of conditional probability:

$$Pb(A|B) = \frac{Pb(A \cap B)}{Pb(B)} \tag{1}$$

This study considered $x > 0$, and supposed that the value of $F_0(t)$ is given. To find $F_x(t)$, consider that the person has survived from age 0 to x, and the probability that the person aged x survived for t years until the person ages $x + t$ is found. Using the definition of conditional probability:

$$F_x(t) = Pb\ (T_0 \leq x + t | T_0 > x) \tag{2}$$

$$= \frac{Pb(x < T_0 \leq x + t)}{Pb(T_0 > x)} \tag{3}$$

$$= \frac{F_0(x+t) - F_0(x)}{1 - F_0(x)} \tag{4}$$

In terms of survival functions,

$$S_x(t) = Pb\ (T_0 \leq x + t | T_0 > x) \tag{5}$$

$$= \frac{Pb(x < T_0 \leq x + t)}{Pb(T_0 > x)} \tag{6}$$

$$= \frac{S_0(x+t)}{S_0(x)} \tag{7}$$

However, in actuarial notation, ${}_tq_x$ is more commonly used to denote $F_x(t)$, and ${}_tp_x$ denotes the survival function $S_x(t)$. There are other mathematical operations involved such as $S_x(t+u)$, comprehend that the person aged x, survived t years, and is expected to survive another u years. To depict in an equation form, equations (8) and (9) are obtained.

$$S_x(t+u) = S_x(t) \cdot S_{x+t}(u) = S_x(u) \cdot S_{x+u}(t) \tag{8}$$

$${}_{t+u}p_x = {}_tp_x \cdot {}_up_{x+t} = {}_up_x \cdot {}_tp_{x+u} \tag{9}$$

In addition, computing those formulae are usable if and only if the probabilities are already available. In cases of unavailability of probabilities:

$$Pb(X = x) = \frac{\text{number of respective elements in event } X}{\text{number of total respective population}} \tag{10}$$

In terms of the survival probability:

$${}_tp_x = \frac{\text{number of people aged x surviving to } x+t}{\text{number of total people aged } x} \tag{11}$$

Using l_x to represent the number of people surviving to age x. The ${}_tp_x$ formula was obtained as follows:

$${}_tp_x = \frac{l_{x+t}}{l_x} \tag{12}$$

To represent the number of people who dies between x and $x+1$, use d_x and define as follows:

$$d_x = l_x - l_{x+1} \tag{13}$$

Using the probability definition, the death probability can be written as follows:

$${}_tq_x = \frac{d_x}{l_x} \tag{14}$$

This study used the death probability in respect to the age groups, genders, and states. By using the probability definition

$$m_{x,t} = \frac{D_{x,t}}{E_{x,t}} \tag{15}$$

where,

$m_{x,t}$ = mortality rate for specific age group x at time t,
$D_{x,t}$ = number of deaths for specific age group x at time t,
$E_{x,t}$ = total number of people in specific age group x at time t.

Assumptions

The following assumptions are used in the calculations:

- Assumption 1: the population growth rate per gender and age groups are assumed to be the same for every month in each quarter. This is due to the availability of the said data is only in a quarterly basis.
- Assumption 2: the population growth rate per state is assumed to be constant through the year.

This is due to the availability of the said data is only in a mid-year basis.

Estimating the Mortality Rates Against Age Groups and Genders

The data of total quarterly population by age groups and gender from 2020 until 2021 is obtained from the Ministry of Health Malaysia (Kementerian Kesihatan Malaysia, 2021). As both gender and age factors are needed, this study used the formula as follows:

$$= \frac{\text{Total gender population for quarter}_i}{\text{Total population for quarter}_i} \times \text{Population of age group}_j \text{ for quarter}_i \tag{16}$$

Estimating the Mortality Rates Against Age Groups and States

To estimate the mortality rates against age group and states, the data of total yearly population by states and genders from 2020 until 2021f is obtained from obtained from the Ministry of Health Malaysia (Kementerian Kesihatan Malaysia, 2021).

Analysing the Multi-factorized Mortality Rate

To analyse the age-specific mortality rate, a graph of mortality rate against time is plotted using Microsoft Excel. The graph trends are observed, which led to the analysis of the graph – the part where this study explains the reasons behind the fluctuations with available supporting evidence from various sources.

RESULTS AND DISCUSSION

Age-Wise Mortality Rates

The mortality rate formula is used to get the q_x. Using the $q_x$formula, by dividing each input with its respective population quarter, the results obtained are as in Figures 3 and 4. Figure 3 subtly reveals the phases of COVID-19 deaths for the male populations. During the first COVID-19 appearance, the q_x fluctuated from 0% to 0.0005%, which is still considered critical yet controllable, as it was Malaysia's first time combatting this type of virus. The graph volleyed between the middle of May 2020 until September 2020, where it started to show an increasing trend again.

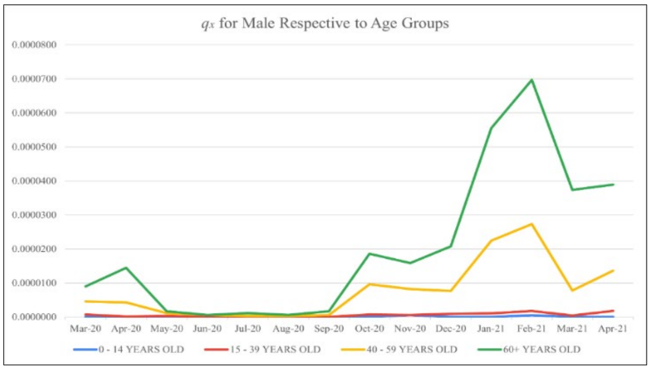

Figure 3. q_x for Males by Age Groups

Figure 3 also showed q_x for males by categorized age groups, from March 2020 until April 2021, where the trend is the same as the death numbers, where the elderly group was calculated to have the highest q_x in contrast to other 3 age group categories. This has shown to us despite the fact that the middle-aged groups and the adult's group being more involved in the economic sectors, the age factor displayed the largest effect for the male's case.

Observing the female mortality rates of all age groups, all of them seem to stabilise from the very beginning until September 2020, where the elderly groups peaked a little in October 2020. For the female age groups, the elderly group is the highest during the first phase of COVID-19. With the same trend of fluctuation until September 2020, the group rose to approximately 0.00002%, before the elderly group peaked in November 2020 and January 2021. In February 2021, the elderly group rose in the blink of an eye where the death number accounted that month was 0.00007%. The trend seemed to slow down in March 2021 but increased again in April 2021 onwards. This result also shows that the age factor affected the mortality rates more than the fact that the working age groups are mainly from the adults and the middle-aged groups. It can also be deduced that the elderly are more susceptible of death when infected with COVID-19 compared to the other age groups.

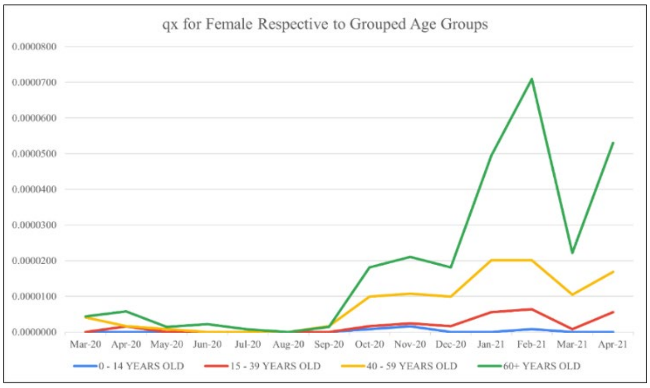

Figure 4. q_x for Females by Age Groups

Comparing both male and female mortality rates, the Figure 5 was obtained. During the COVID-19 pandemic, men in Malaysia have experienced higher mortality rates compared to women. According to data from the Ministry of Health Malaysia, as of December 2021, men accounted for 58% of COVID-19 deaths in the country (Kementerian Kesihatan Malaysia, 2021). There are several possible explanations for this gender difference in COVID-19 mortality. One possibility is that men may be more likely to engage in behaviours that increase their risk of contracting the virus, such as not wearing masks or not following social distancing guidelines. Men may also be more likely to work in high-risk occupations, such as healthcare or essential services, which could increase their exposure to the virus. Additionally, men may be more likely to delay seeking medical care, which could exacerbate their symptoms and increase the risk of death. It is important to note that the higher mortality rate among men is not unique to Malaysia. Many other countries have also reported higher mortality rates among men during the COVID-19 pandemic. Overall, the data suggests that men in Malaysia have experienced higher mortality rates from COVID-19 compared to women. It is important to address the factors that contribute to this difference to reduce the burden of the pandemic on men and the overall population.

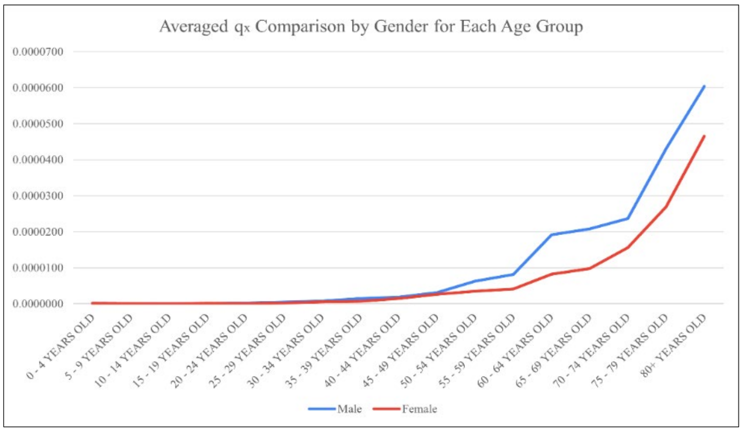

Figure 5. Averaged q_x by Gender

State-Wise Mortality Rates

According to Figure 6, for starters, Johor recorded the highest number of COVID-19 deaths, which is higher than ten deaths, before the numbers fluctuated until September 2020, where the COVID-19 death number of Sabah increased steeply to seventy deaths in October 2020. In January 2021, Selangor peaked at 75 and approximately 80 in February 2021 before declining back to approximately thirty deaths in March 2021. The numbers were bouncing upwards afterwards. From March 2020 to April 2020, Wilayah Persekutuan Kuala Lumpur experienced highest mortality rates compared to other states before the rates also fluctuated until September 2020. Onwards, Sabah peaked in October 2020 and Wilayah Persekutuan Labuan peaked and experienced the highest COVID-19 mortality rates (0.0006). Even though Wilayah Persekutuan Labuan experienced a low death number unlike Sabah, the small population size caused the mortality rates to be high.

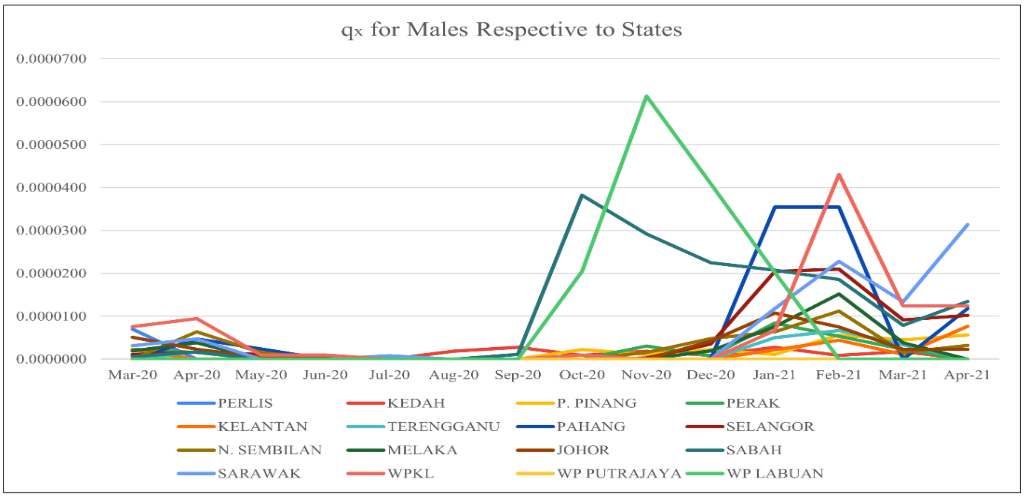

Figure 6. q_x for Males by States

To make the analysis easier, this study further grouped the states by their regions, namely the Northern region, the East Coast, the Central region, the Southern region, and Borneo region as in Figure 7. At the start of the spread, the southern region recorded the highest rates, fluctuating between 0.0 to 0.000005. This is due to the higher infection rates during that time in the southern region. However, after a stagnant period until September 2020, the Borneo region's mortality rates spiked to 0.000023. The known reason behind the spike is due to the State Election in Sabah, which then caused the state to lose control of COVID-19, and hence obtained a higher infection rate, and consequently higher mortality rates. However, in February 2021, the central region topped the rates, by achieving a value higher than 0.000025, the biggest ever recorded during the time span. This is due to the reopening of the sectors for which the economic sector is developing, but at the cost of higher infection rates.

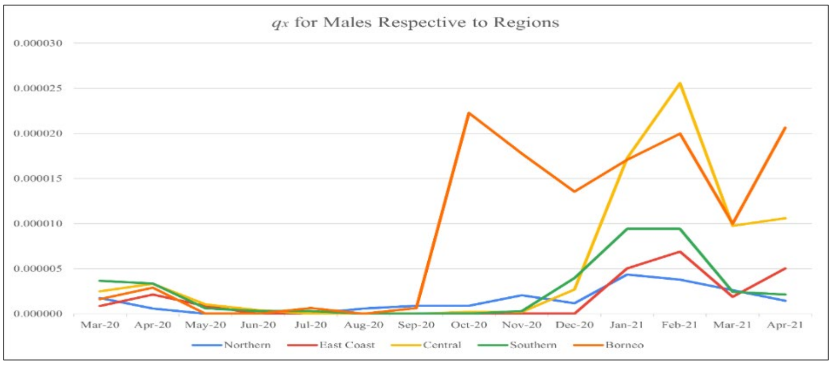

Figure 7. q_x for Males by Regions

For females, COVID-19 death numbers remained below 10 deaths until September 2020, where Sabah peaked in October 2020 until November 2020 before declining again. In January 2021, Johor had the highest mortality rates until February 2021 before declining back in March 2021 and bounced back in April 2021. The female mortality rates fluctuated under 0.000005 from March 2020 until September 2020 before both Sabah and Wilayah Persekutuan Labuan reached the same rate of mortality. In January 2021, Wilayah Persekutuan Labuan recorded the highest number of COVID-19 mortality rate (0.000045). This might be due to the movement of the people in that region during the timespan, which the regional mortality rates show a clearer picture of the situation.

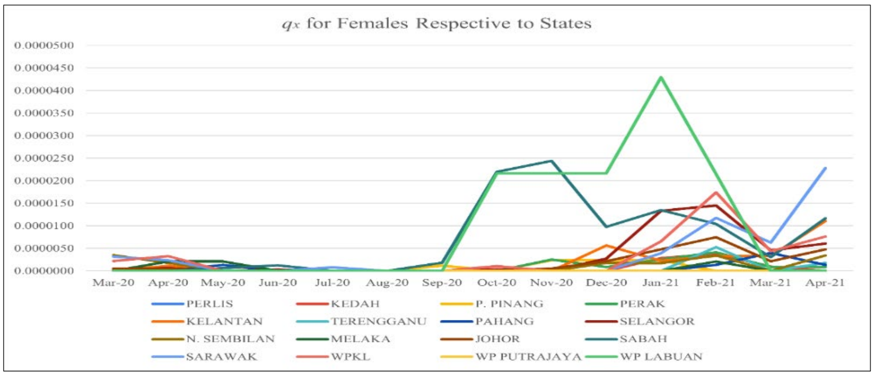

Figure 8. q_x for Females by States

Looking at the regional mortality rates results, the pattern during the start of the spread is much more unsubtle than the males, as the numbers only seems to fluctuate at the very beginning, before it also spiked in September 2020. Same to the male's regional mortality pattern, the Borneo region spiked during that time due to the State Election held. In February 2021, the central region also spiked, as this was a consequence of loosened control of the movement for the re-opening of the economic sectors. The Borneo region, however spiked back in April 2021, much subtler than the males' pattern in the same month.

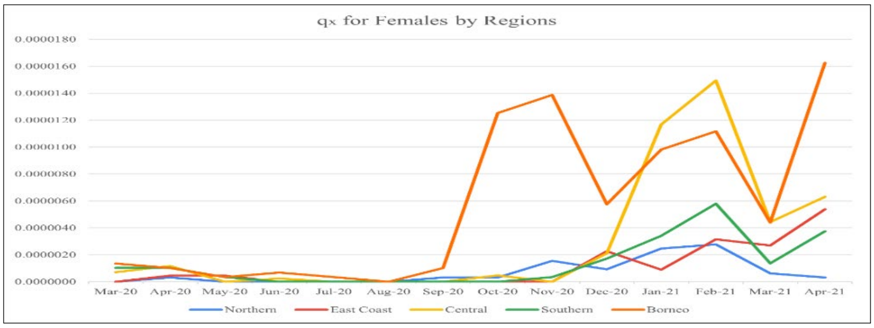

Figure 9. q_x for Females by Regions

Comorbidities of The Mortality Rates

In Figure 10, we can see that roughly for both genders, hypertension, diabetes, heart disease and kidney disease top the list of most diagnosed comorbidities or health backgrounds amongst COVID-19 deaths. Now, by putting both genders side to side, this study found that the comorbidities found in males are higher than that in the females for all top comorbidities except for obesity. Taking the total gender-wise population into account, this study also found that the percentage of hypertension and diabetes is higher in females in comparison to males despite the numbers being higher in the latter, aside from obesity. With the fact that the males' death numbers and mortality rates were higher than that of the females, this study deduced that a female with hypertension or diabetes or obesity, had a higher mortality rate than that of males with the same comorbidities.

Figure 10 shows that hypertension had been the top health issue diagnosed among the COVID-19 deaths. There are several reasons why hypertension is associated with a higher risk of severe illness and death from COVID-19 in Malaysia. One reason is that people with hypertension are more likely to experience severe symptoms and complications from the virus, including difficulty breathing, organ failure, and death. The patients are also subjected to a higher risk of developing complications from COVID-19. It is believed that the virus may cause inflammation in the body, which can exacerbate hypertension and make it harder for the body to fight off the virus. Additionally, hypertension can weaken the immune system, making it more difficult for individuals to recover from the virus.

The second most diagnosed health issue is diabetes. The reason is that people with diabetes are more likely to have other underlying health conditions that increase the risk of severe illness from COVID-19. For example, many people with diabetes also have high blood pressure, heart disease, or obesity, all of which can make the symptoms of COVID-19 more severe. Furthermore, people with diabetes may also have difficulty managing their blood sugar levels during times of stress, such as during an illness, which can also increase the risk of severe illness from COVID-19. In addition, as diabetes is a chronic disease, most of the people with diabetes in Malaysia may have poor control over their blood sugar level due to lack of access to healthcare, education, and support, which also increases their risk of severe illness from COVID-19.

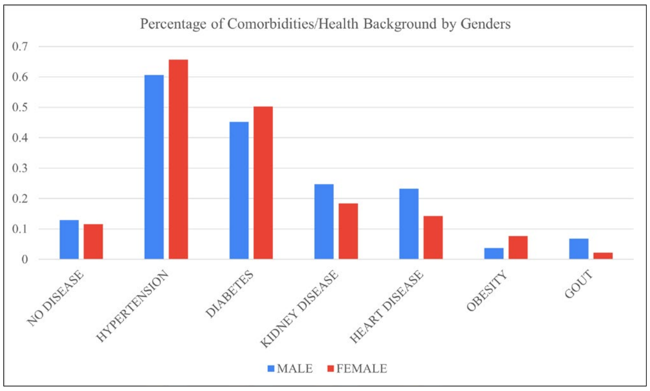

Figure 10. Comparison of Comorbidities Numbers and Percentage between Males and Females

Another possible reason is that hypertension and diabetes are common in Malaysia, and many individuals with these conditions may not have had adequate access to healthcare and education on how to manage their conditions prior to the COVID-19 pandemic. This could have led to a higher proportion of individuals with these conditions developing severe illness and death from COVID-19.

The findings of this study highlighted the importance of controlling hypertension diabetes to reduce the risk of severe illness and death from COVID-19. This is especially true for older individuals, who are more likely to have hypertension and are at higher risk of suffering from severe COVID-19 outcomes.

CONCLUSION

This study was conducted to estimate the excess mortality rate trend for age groups, each gender, each state, and the top comorbidities or health issues that contributed to COVID-19 deaths. To determine the mortality rate trend for each age groups, this study employed the q_x methodology, where the raw mortality data used were cited from Kementerian Kesihatan Malaysia, 2021, along with the quarterly population data provided by Department of Statistics Malaysia as of 2022. The mortality data is taken from March 2020 until April 2021 as to get a view on how the mortality trend behaved for a year, with the fact that the first COVID-19 death recorded was on 17th of March 2020. The quarterly population on the other hand, is used, as it was the most frequent data that is available for this study's purpose, which brought this study to assume that the population growth rate is constant throughout the quarter. With that assumption, this study can then determine that the worst age group affected by COVID-19 is the elderly group. With the known higher original mortality rates, plus the tendency for the elderly to be diagnosed with several diseases, was among the inferences of why the stated age group is the most vulnerable. As for the time-wise description for the trend, all age groups displayed the same fluctuation until May 2020 and June 2020, as the government deployed the Movement Control Order, and this order is proven to be successful in stagnating the trend, only until September 2020 when the cases rose and peaked in February 2021. Gender-wise, this study deduced that the male mortality rates are higher than that of the females. Firstly, it is obvious that from the death number data, as the number of male deaths is more frequently recorded for all ages. Secondly, analysing the q_x trend of both males and females as in Figure 11 acquired the finding of the higher COVID-19 q_x in males, starting at the age group 44 – 49 years old. Next, this study also determined the state with the highest recorded death numbers and death rates. This objective also utilized the same mortality rate formula, and gender population data. However, the limitation is that the data available for the state population is only available in a yearly data, which had forced this study to assume that the population growth rate remains the same throughout the year. With that, this study concludes that the mortality rates for Wilayah Persekutuan Labuan is the highest compared to other states. Even though the numbers of COVID-19 deaths were higher in Sabah and Selangor, since the populations are larger on both latter states in comparison to Labuan. Finally, this study concluded that major health issues among the COVID-19 deaths are hypertension, diabetes, kidney disease, heart disease and dyslipidaemia.

REFERENCES

Aburto, J. M., Scholey, J., Kashnitsky, I., Zhang, L., Rahal, C., Missov, T. I., Mils, M.C., Dowd, J.B. Kashyap, R. (2022). Quantifying Impacts of The COVID-19 Pandemic Through Life-Expectancy Losses: A Population-Level Study Of 29 Countries. *International Journal of Epidemiology*, **51(1)**: 1 12.

Ahrenfeldt, L.J., Otavova, M., Christensen, K., & Lindahl-Jacobsen, R. (2020). Sex and Age Differences in COVID-19 Mortality in Europe. *Wiener klinische Wochenschrift*, **133(6)**: 393 –397.

Anaele, B. I., Doran, C., & McIntire, R. (2020). Visualizing COVID-19 Mortality rates and African-American Populations in the USA and Pennsylvania. *Journal of Racial and Ethnic Health Disparities*, **8(6)**: 1 – 8.

Azizi, H., Esmaeili, E. D., & Fakhari, A. (2020). Chanllenges and Accurate Estimates of Mortality and Case-fatality Rates due to COVID-19. *New Microbes and New Infections*, **38**: 1 – 2.

Bernama. (2020, March 17). *COVID-19 Chronology in Malaysia*. BERNAMA.com: https://bernama.com/en/general/news_covid-19.php?id=1821902

Blandford, J. I., Jong, N. B.-d., Schouten, S. E., W, F. A., & Araujo-Soaraes, V. (2022). Navigating Travel In Europe During The Pandemic: From Mobile Apps, Certificates And Quarantine To Traffic-Light System. *Journal of Travel Medicine*, **29(3)**: 1 – 25.

Dessie, Z. G., & Temesgen, Z. (2021). Mortality-Related Risk Factors Of COVID-19: A Systematic Review And Meta-Analysis Of 42 Studies And 423,117 Patients. *BMC Infectious Diseases*, **21(1)**: 1 – 28.

Goldstein, J. R., & Lee, R. D. (2020). Demographic Perspectives on the Mortality of COVID-19 and Other Epidemics. *PNAS Latest Articles*, **117 (36):** 35 – 41.

Kementerian Kesihatan Malaysia. (2020, March 17). *Situasi terkini COVID-19 di Malaysia 17 Mac 2021*. Kementerian Kesihatan Malaysia: https://covid-19.moh.gov.my/terkini/032020/situasi-terkini-17-mac-2020.

Kementerian Kesihatan Malaysia. (2021, May 29). *Situasi Semasa Jangkitan Penyakit Coronavirus 2019 (COVID-19) di Malaysia.* Kementerian Kesihatan Malaysia: https://covid-19.moh.gov.my/terkini/2021/05/situasi-terkini-covid-19-di-malaysia-29052021/Kenyataan_Akhbar_KPK_COVID-19_29052021.pdf

Kementerian Kesihatan Malaysia. (2021, August 2021). *Situasi Semasa Jangkitan Penyakit Coronavirus 2019 (COVID-19) Di Malaysia 12 Ogos 2021.* Kementerian Kesihatan Malaysia: https://covid-19.moh.gov.my/terkini/2021/08/situasi-terkini-covid-19-di-malaysia-12082021/Kenyataan_Akhbar_KPK_COVID-19_12082021.pdf

Kementerian Kesihatan Malaysia. (2022, March 11). *Fasa Peralihan ke Endemik*. COVID-19 Malaysia Kementerian Kesihatan Malaysia: https://covid-19.moh.gov.my/reopeningsafely/semasa/2022/03/fasa-peralihan-ke-endemik-11032022

Liu, X., Zhang, D. S., & Li, X. Z. (2020). Containing COVID-19 in Rural and Remote Areas: Experiences from China. *Journal of Travel Medicine*, **27(3)**: 1 – 4.

Ministry of Health Malaysia. (2022, June 21). *COVID-19 Cases in Malaysia*. COVIDNOW: https://covidnow.moh.gov.my/cases.

Ministry of Health Malaysia. (2022, June 22). *COVID-19 Deaths in Malaysia*. COVIDNOW: https://covidnow.moh.gov.my/deaths/

Petti, S., & Cowling, B. J. (2020). Ecologic Association between Influenza and COVID-19 Mortality Rates in European Countries. *Epidemiology and Infection*, **148**: 1 – 21.

Richardson, S., Hirsch, J. S., & Narasimhan, M. (2020). Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. *Journal of American Medical Association*, **323(20)**: 1 – 10.

See, K., Liew, S., Ng, D. C., Che, E., Khoo, E., C.H, S., . . . Ibrahim, H. (2020). COVID-19: Four Paediatric Cases in Malaysia. *International Journal of Infectious Diseases*, **94**: 1 – 10.

Vasishtha, G., Mohanty, S. K., Mishra, U. S., Dubey, M., & Sahoo, U. (2021). Impact of COVID-19 Infection on Life Expectancy, Premature Mortality, and DALY in Maharashtra, India. *BMC Infectious Diseases,* **21(1)**: 1 – 11.

World Health Organization (WHO). (2020, August 4). *Coronavirus Disease (COVID-19) situation report.* World Health Organization (WHO): https://apps.who.int/iris/rest/bitstreams/1289937/retrieve

Yang, X., Hou, C., & Shen, Y. (2022). Comorbidities and Outcomes of Hospitalized Patients With Coronavirus Disease 2019 (COVID-19) in Wuhan, China. *Journal of American Medical Association*.

Yin, T., Li, Y., & Luo, Z. (2021). Prevalence of Comorbidity in Chinese Patients With COVID-19: Systematic Review and Meta-Analysis Of Risk Factors. *BMC Infectious Disease*, *,* **21(1)**: 1 – 13.