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Determinants of New Confirmed COVID-19 Cases in Namibia: A Retrospective Observational Analysis

Opeoluwa Oyedele
Senior Researcher, Department of Computing, Mathematical and Statistical Sciences,
School of Science, University of Namibia, Windhoek, Namibia
Monique Van Wyk
Researcher Student, Department of Computing, Mathematical and Statistical Sciences,
School of Science, University of Namibia, Windhoek, Namibia

Abstract:
Although little is known about the contributing factors of new confirmed cases of COVID-19 in Namibia besides no masking, no sanitizing and no social distancing, there is a need for an exhaustive study to be done to explore the factors contributing to new confirmed cases in the country. In this retrospective study, the Negative Binomial regression technique was used to examine the factors contributing to the new confirmed cases in Namibia using the data collected from the COVID-19 reports from Ministry of Health and Social Services official Facebook page, Worldometer and WHO webpage from 13 March 2020 to 31 December 2021. Results from this study revealed that Khomas, Erongo and Otjozondjupa regions had the most reported confirmed COVID-19 cases in the country. In addition, the weather season (p=0.003), national events (p<0.001), vaccination period (p<0.001), sex (p=0.010) and region (p=0.018) were significant contributors to new confirmed cases. It is, therefore, recommended that the Ministry of Health and Social Services, together with governmental and non-governmental/aid organizations, use these findings in their efforts to further curb the spread of the COVID-19 virus in the country, especially during the current wave of the virus as well as in the event of a potential sixth and seventh wave outbreak.

Keywords: *COVID-19, COVID-19 infection, negative binomial regression, Namibia*

1. Introduction

1.1. Background of the Study

First detected in Wuhan City, China, in 2019 during an outbreak of respiratory illness cases, Coronavirus disease 2019 (COVID-19) is an infectious disease that affects the respiratory system (World Health Organization [WHO], 2021) and is caused by a novel coronavirus called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), formerly known as 2019-nCoV (Cennimo, 2022). COVID-19 outbreak was first reported to World Health Organization (WHO) on 31 December 2019, who later declared it a worldwide (global) pandemic on 11 March 2020 (Cennimo, 2022; Cucinotta & Vanelli, 2020). According to WHO (2021), anyone can get infected with COVID-19 and become seriously ill or die at any age, with most people infected with the virus experiencing mild to moderate respiratory illness and recovering without requiring special treatment. However, some people became seriously ill and required medical attention, like older people and those with underlying medical conditions like cardiovascular disease, diabetes, chronic respiratory disease, or cancer. The virus can spread from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak or breathe. These particles ranged from larger respiratory droplets to smaller aerosols (World Health Organization, 2021). Possible COVID-19 infection symptoms included fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting and diarrhoea. However, these are not all the possible symptoms but rather some of the most common symptoms experienced by people with COVID-19 (Centers for Disease Control and Prevention, 2021).

Confirmed cases of COVID-19 can be diagnosed as mild, moderate, severe or critical. A mild diagnosis is when individuals have a fever, cough, sore throat, headache, muscle pain, nausea, vomiting, diarrhoea, or loss of taste and smell but do not have/experience shortness of breath or abnormal chest imaging (Centers for Disease Control and Prevention, 2021a), while a moderate diagnosis is when an individual shows evidence of lower respiratory disease during clinical assessment or imaging (Son et al., 2021). On the other hand, a severe or critical diagnosis is when individuals have respiratory failure, septic shock, and/or multiple organ dysfunction (Son et al., 2021). People over the age of 45 years were more likely to fall in the severe or critical diagnosis category, with more than 80% of the global COVID-19 deaths reported to have occurred among people over the age of 65 years and more than 95% of COVID-19 deaths occurred among people older than 45 years (Centers for Disease Control and Prevention, 2021b). Moreover, people with underlying medical conditions like hypertension and diabetes, regardless of their ages, have shown worse prognosis (Sanyaolu et al., 2020).

Diabetic patients with COVID-19 have increased morbidity and mortality rates and have been linked to more hospitalization and intensive care unit admissions, while people with chronic obstructive pulmonary disease or any respiratory illnesses have been reported to be at higher risk for severe illness from COVID-19 (Sanyaolu et al., 2020).

1.2. Overall Pattern of COVID-19

To date, over 7 million people are confirmed to have been killed by the COVID-19 virus, making it one of the deadliest pandemics in human history since its first detection in late 2019 in Wuhan, China and its rapid spread to other areas across the globe in early January 2020. The overall pattern and its severity came in a series of COVID-19 waves with surges in new confirmed cases followed by declines due to several factors such as human behavior, the effectiveness of vaccines over time, waning immunity and relaxation of public policies, infection prevention measures, number of people who were vulnerable because they had not developed some immunity (whether from natural infection or through vaccination), and changes to the virus itself in the form of variants and mutations (Maragakis, 2021). The major waves of COVID-19 infections after the initial onset in 2019 were largely caused by the emerging variants due to mutated variants. Up till now, five COVID-19 waves have been experienced across the globe since the first outbreak of the virus in 2019, while five variants of the virus have been experienced. These variants of concern were the alpha (B.1.1.7), beta (B.1.351), gamma (P.1), delta (B.1.617.2), and omicron (B.1.1.529) variants as named by the WHO, with the omicron variant responsible for the largest surge since the first outbreak of the virus in 2019. Subject to different countries' surveillance and testing of the virus, the first COVID-19 wave (March to August 2020) was caused by the wild variant imported from China, while the second wave (August 2020 to March 2021) was mainly due to a mutated variant (B.1.36) which had travelled from China to western countries (Amin et al., 2022). The third wave (April to June/July 2021) was mainly related to a new variant (B.1.1.413), first identified in western countries, including Europe and Canada, while the fourth wave (July/August to October/November 2021) was due to the alpha variant (first identified in England). The fifth and more recent wave (December 2021 to present) was mainly caused by the delta variant first detected in India (Amin et al., 2022).
In the first COVID-19 wave, respiratory symptoms were the main clinical manifestations. However, during the second and third waves, gastrointestinal complaints followed by neurological manifestations with peripheral involvement were added, while during the fourth and fifth waves, central nervous system manifestations were added. Overall, coughing, difficulties in breathing, and fever remained the leading diagnoses throughout the pandemic (Amin et al., 2022). Globally, as of 31 January 2022, a total of 377,342,671 COVID-19 cases were recorded, with 5,689,754 deaths and 298,561,050 recoveries (Worldometer, 2022). The majority of these cases were reported in the United States of America, India, Brazil, United Kingdom, France, Russia, Turkey and Italy, with each of these countries reporting cases in the millions. The United States of America had the highest total of recorded cases of 75,947,094 with 909,293 recorded deaths, while India had 41,466,711 recorded cases with 496,268 recorded deaths and Brazil had 25,426,744 recorded cases with 627,138 recorded deaths (Worldometer, 2022). France had 19,140,730 recorded cases with 130,931 recorded deaths, the United Kingdom had 16,468,522 recorded cases with 155,698 recorded deaths, and Russia had 11,861,077 recorded cases with 331,349 recorded deaths, while Turkey had 11,619,882 recorded cases with 87,416 recorded deaths (Worldometer, 2022). In Africa, South Africa had the highest total of recorded cases of 3,605,222 with 95,093 recorded deaths, followed by Morocco (1,132,716 cases and 15,400 deaths), Tunisia (909,813 cases and 26,288 deaths), Ethiopia (465,158 cases and 7,337 deaths) and Libya (429,666 cases and 6,017 deaths) (Worldometer, 2022). However, this does not mean that Namibia is not plagued by the COVID-19 virus, as there were 155,899 cases with 3,967 total deaths reported in Namibia as of 31 January 2022 (Worldometer, 2022).

Although quite a number of vast studies have been done on COVID-19 confirmed cases and deaths globally, these studies thus far have shown no known curative treatments for COVID-19 besides early detection, vaccination, testing and diagnosis to prevent the widespread of the deadly virus and ultimately death of the infected persons. Moreover, numerous studies on the incidence of COVID-19 have indicated a clear influence of a variety of geographical, environmental, social and economic factors, as well as government responses on the magnitude and spread of COVID-19 in each country. These factors included the effectiveness of vaccines over time, human behaviour, infection prevention policies, places where people live or work closely together, and the number of people who are vulnerable because they have not developed some immunity, whether from natural infection or through vaccination (Maragakis, 2021).

1.3. State of Affairs in Namibia

Compared to the numerous research studies on COVID-19 worldwide, including topics such as the morbidity and mortality patterns of the disease, the effectiveness of different public health interventions, and the impact of social and cultural factors, among others, Namibia still lacks such comprehensive study at the national level. Like many other countries, Namibia has been affected by the COVID-19 pandemic, with the virus spreading rapidly across all 14 regions of the country. In Namibia, COVID-19 was first reported in March 2020 and as of 13 June 2023, over a total of 171,310 confirmed cases and over 4,090 cumulative deaths were recorded (World Health Organization, 2023). The impact of COVID-19 on the health and economy of Namibia has been significant, with many individuals being infected and a significant number of deaths reported. Despite various measures taken by the government, the virus continues to spread, resulting in a growing concern for the health and well-being of the Namibian population. Containment measures such as the closing of borders, national lockdowns, compulsory wearing of face masks, social distancing, quarantines and the use of hand sanitizers were strictly implemented to reduce the spread of the virus in the country.

The implementation of COVID-19 precautions and measures such as practising physical/social distancing, hand washing/sanitizing and mask-wearing helped to keep the viral transmission of the virus lower, waning immunity, relaxation of public policies, and relaxation of infection prevention measures played a role in the rise of confirmed cases in the country. Cases tended to rise in areas where fewer people were wearing masks. More people were gathering indoors to eat, drink, celebrate, and socialize without observing physical/social distancing, fewer people were vaccinated, and they were in places where people lived or worked closely together. In July 2021 alone, driven by the delta variant ravaging the country, Namibia recorded close to 24,000 new COVID-19 infections and over 1,100 deaths, bringing the accumulated number of infections recorded in the country close to 70,000 with over 2,000 deaths between May and July 2021 (third wave). In May 2022, the country entered a fifth wave of COVID-19 infections amid rising infections and hospitalizations in the country, with 103 positive cases from 848 results within a 24-hour reporting cycle, representing a 12.1% positivity ratio (The Brief, 2022). Among the patients admitted in the hospitals countrywide, the majority in intensive care units were unvaccinated, while the number of infections in the school environment was surging during this period due to the detection of two new omicron sub-variants that were driving a surge of COVID-19 infections in neighbouring South Africa.

Although the COVID-19 infection might have subsided, with a few confirmed cases being reported in some regions in Namibia, little is known about the contributing factors of COVID-19 besides no masking, no sanitizing and no social distancing. Thus, there is a need for a profound study to be done to explore the factors contributing to the new confirmed cases, especially in Namibia, with over 171,310 confirmed cases despite all the mandatory COVID-19 protocols/measures put in place to curb its spread since its first detection in March 2020. For this reason, this study aimed to fill this gap by examining the contributing factors of new confirmed COVID-19 cases in Namibia, thereby further assisting in curbing the spread of the deadly virus in the country. Findings from this study may serve as inputs for researchers and the Ministry of Health and Social Services (MOHSS) to further enhance their prevention and control measures for COVID-19 in the country.

2. Materials and Methods

This study made use of a quantitative research approach by gathering the daily COVID-19 new cases reported in Namibia, as documented in the Ministry of Health and Social Services (MOHSS) reports on their official Facebook page, the Worldometer, and the WHO webpage. The validity of the data obtained from the ministry's official Facebook page was assured by fact-checking with the daily information published in:

- The Namibia COVID-19 Situation Reports,
- The Coronavirus disease (COVID-19) Weekly Epidemiological Updates, and
- The Monthly Operational Updates publications by the WHO for each day of the study period (13 March 2020 to 31 December 2021).

The Namibia COVID-19 Situation Reports provides daily updates on new cases and public health interventions to control the pandemic, while the COVID-19 Weekly Epidemiological Update provides an overview of the global, regional and country-level COVID-19 cases and deaths, highlighting key data and trends as well as other pertinent epidemiological information concerning the COVID-19 pandemic. The Monthly Operational Updates report on WHO and their partners' actions in response to the pandemic. All these reports are freely available at
https://www.afro.who.int/publications/namibia-covid-19-situation-reports-number-1-211
and https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports.

The COVID-19 tests performed for the MOHSS reports were collected voluntarily from the members of the Namibian population. However, not all the whole population were tested, as people volunteered to get tested for COVID-19 when sick, showed some known symptoms of COVID-19 or wanted to travel outside the country. The study period for this study was from 13 March 2020 until 31 December 2021 and included variables such as the number of new confirmed cases, day of the week, number of new recoveries, number of male cases, number of female cases and number of new cases from regions. These variables were selected because they were the variables that were consistently available and captured in the daily COVID-19 case reports collected by MOHSS. Furthermore, the daily date on which the cases were captured was used to identify the type of national events in the country as well as the vaccination periods and weather season periods. Also, looking at how the new cases differ across different characteristics such as sexes, regions, national events, weather seasons and so on (as recorded in the dataset), as well as if/how these characteristics played a contributing role in the spread of daily confirmed COVID-19 cases in the country were also of relevance. All revealing information about the identities of the confirmed cases was already excluded in the daily reports by MOHSS, Worldometer and WHO before they were made freely available online.

2.1. Statistical Analysis

The negative binomial regression technique is a generalization of the Poisson regression technique, which loosens the restrictive equal dispersion assumption of the Poisson regression (NCSS Software, 2021). In the Poisson regression technique, the mean and variance of the distribution are assumed to be equal (i.e., equal dispersion) (Oyedele & Lubbe, 2018). However, most often, this is not the case for most count data, as the mean is either less or more than the variance (i.e., under- or over-dispersion). For this reason, statisticians and data analysts most often prefer to use the Negative Binomial regression technique to model unequally dispersed count data. Conversely, both the Poisson and Negative Binomial regression techniques are similar to the regular multiple (linear) regression technique, except, here, the response variable (y) is an observed count with non-negative integer values (Oyedele & Lubbe, 2018; Zwilling, 2013).

With the Negative Binomial regression, y follows the Negative Binomial distribution, which is defined in terms of the number of trials until the r^{th} success (NCSS Software, 2021). This is slightly comparable to the general Binomial distribution, except in this distribution, the number of successes is fixed while the number of trials is counted, whereas, in the general binomial distribution, the number of trials is fixed while the number of successes is counted. Generally, the Negative Binomial regression modelling technique is specified as:

$$\ln(\mu) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \epsilon$$

For a set of explanatory variables $x_1, x_2, \ldots, x_p$, where μ is the mean of y, β_0 and $\beta_1, \beta_2, \ldots, \beta_p$ are the intercept and unknown parameters that are estimated from a set of data, respectively, while ϵ is the error term (NCSS Software, 2021; Oyedele & Lubbe, 2018). In this study, the explanatory variables were the number of new recoveries, number of males' cases, number of females' cases, day of the week, number of new cases from regions, national events, vaccination period and weather season, while the response variable was the number of new (confirmed) cases. These variables were selected because they were the variables that were consistently available in the daily COVID-19 case reports collected by MOHSS. Microsoft Excel (2019) was used to compile the study dataset, while all data analysis aspects were performed using the R software (version 4.1.2).

To identify the best-fit model to use in identifying the contributing factors of confirmed (new) COVID-19 cases, seven different model structures were considered and their Akaike Information Criterion (AIC) and Log-Likelihood (LL) values were calculated. To be precise, all variables that were consistent in all the MOHSS COVID-19 reports were selected and used in model 1. Afterwards, all the significant (explanatory) variables from model 1 were later used as (explanatory) variables in model 2, and then the resulting significant variables from model 2 were used as variables in model 3. This continued until there were no more significant variables left to use. As a result, seven possible model structures were created and the best-fit model was identified as the model with the lowest AIC value and the highest LL value.

Although not of interest in this study, most count datasets contain excessive zero values, which causes the regression model to be over-dispersed. In this situation, zero-inflated Poisson and zero-inflated negative binomial regression techniques are most useful. The Zero-inflated Poisson regression modelling is used to model count data that have an excess of zero counts, while the Zero-inflated Negative Binomial regression modelling is used for modeling count variables with excessive zeros and over-dispersed count outcome variables (Allison, 2012; Mumbuu et al., 2022). Since no zero-total number of new confirmed daily cases were recorded in Namibia during this study period, the Zero-inflated model techniques were inappropriate to use in this study.

2.2. Ethical Clearance

This study was carried out by the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval was not sought for this study since the data (daily COVID-19 case reports) was freely available in the public domain. No separate permission was required for data usage and publication. Additionally, this study followed all ethical standards for research without direct contact with human or animal subjects, as there were no names of persons or household addresses recorded in the daily COVID-19 case reports.

3. Results

For a period of 659 days (i.e., from 13 March 2020 to 31 December 2021), a total of 146,491 new confirmed COVID-19 cases were recorded in Namibia, with the trend shown in figure 1. The figure shows a slight increase in the number of reported cases during the winter period of 2020 (i.e., June - August 2020), while a decrease was observed from September to November 2020. However, the number of cases started increasing during the festive season period of 2020 (24 December - 1 January 2021) and stayed constant until the end of May 2021. Likewise, a spike in new cases can be seen from June to July 2021, followed by a decrease during August 2021 and later an increase towards the end of the study period (December 2021).

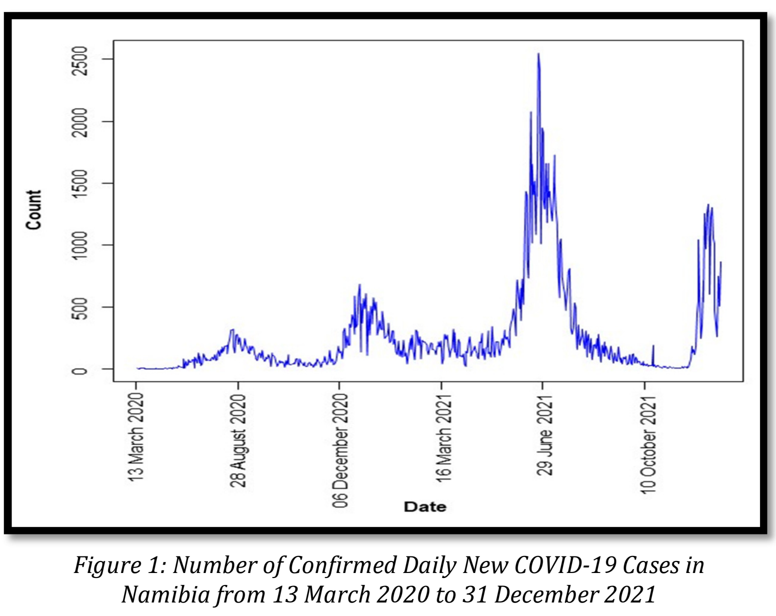

Figure 1: Number of Confirmed Daily New COVID-19 Cases in Namibia from 13 March 2020 to 31 December 2021

Looking at the number of confirmed cases per region in Namibia, in the Khomas region (Figure 2), the number of confirmed cases increased from July to September 2020 and December 2020 to January 2021 but stayed constant between February and April 2021 and rapidly increased during May to the end of July 2021. It later remained steadily low until December 2021. Similar deductions can be observed for the Erongo region (Figure 2) as well. However, in the Omaheke region (Figure 3), cases started increasing between December 2020 and January 2021 and then started decreasing rapidly between March and April 2021. It later spiked up during May to July 2021 and increased in August 2021 until December 2021. Similar deductions can be observed for the Kavango East region as well.

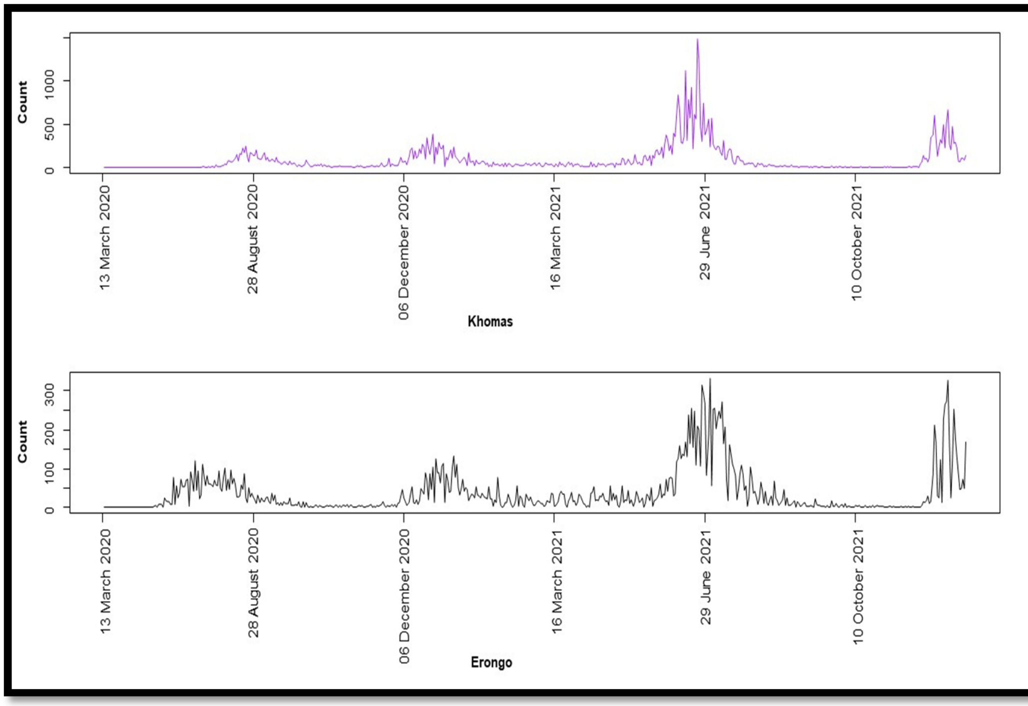

Figure 2: Number of Confirmed Daily New COVID-19 Cases in Khomas and Erongo Regions (13 March 2020 to 31 December 2021)

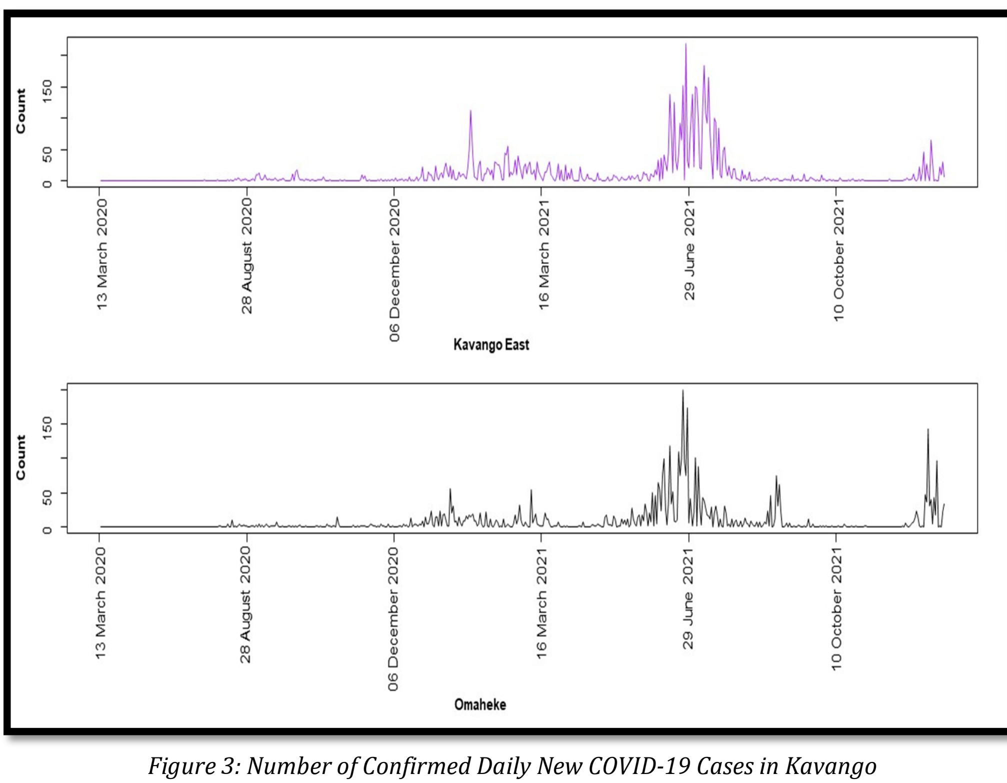

Figure 3: Number of Confirmed Daily New COVID-19 Cases in Kavango East and Omaheke Regions (13 March 2020 to 31 December 2021)

Furthermore, the confirmed COVID-19 case rates per region were estimated and are shown in table 1. For every 1000 people, there were approximately 118 cases reported in Khomas region, 116 cases in Erongo region, 107 cases in //Karas region and 89 cases in Hardap region, while for every 1000 people, there were approximately 8 cases reported in Kavango West region. In addition, the Khomas region, followed by the Erongo and Otjozondjupa regions, can be observed to have the most reported confirmed COVID-19 cases in the country as of 31 December 2021.

	Population Size Per Region*	**New Cases Per Region**	**Rates Per 1000**	**Rates Per 100**
Khomas	415780	48910	117.634	11.763
Ohangwena	255510	5511	21.569	2.157
Omusati	249885	6456	25.836	2.584
Oshikoto	195165	7352	37.671	3.767
Oshana	189237	9899	52.310	5.231
Erongo	182402	21207	116.265	11.627
Otjozondjupa	154342	11301	73.221	7.322
Kavango East	148466	5802	39.080	3.908
Zambezi	98849	3277	33.152	3.315
Kunene	97865	4545	46.442	4.644
Kavango West	89313	693	7.759	0.776
Hardap	87186	7794	89.395	8.940
//Karas	85759	9191	107.172	10.717
Omaheke	74629	4553	61.008	6.101

Table 1: Confirmed Case Rates Per Region
**As of 2016, See (Namibia Statistics Agency, 2017)*

Moreover, the best-fit model to use was model 1 (AIC=6824.854 and LL=-3372.427), with an over-dispersion value of 1.6681, which implies that the variance of the data was higher than the mean. Also, from the diagnostic plots of the best-fit model in figure 4, it can be seen that the residuals exhibit no pattern, thus showing a good indication that the model is appropriate and a good fit for modelling the COVID-19 data.

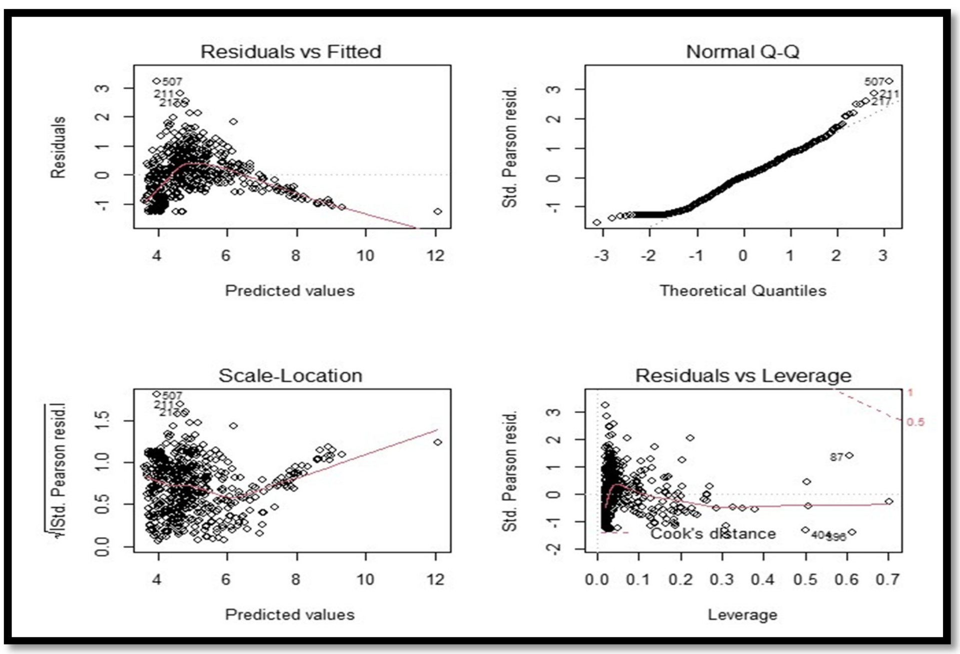

Figure 4: Diagnostic Plots of the Best Fit Model

3.1. Contributing Factors

With a significant probability value at a 5% level of significance, the national events, weather season, vaccination period, sex and region can be concluded as significant contributors to (new) COVID-19 confirmed cases in Namibia. To be precise, the factors contributing to COVID-19 confirmed cases in Namibia were the national lockdowns (p<0.001), Kavango East region (p=0.030), Omaheke region (p=0.034), summer season (p=0.002), male gender (p=0.013) and pre-vaccination period (p<0.001) as shown in table 2. Moreover, keeping all other variables constant, during the national lockdowns, the expected cases of new confirmed COVID-19 cases in Namibia increased by approximately 1 case (EC=1.073, p<0.001, 95% CI: 0.854-1.349) compared to the expected cases when there were no national events taking place in the country. Likewise, during the summer season, the expected cases of new confirmed COVID-19 cases increased by 2 cases (EC=1.862, p=0.002, 95% CI: 1.467-2.365) compared to the expected cases during the spring season, as shown in table 2. On the other hand, during the pre-vaccination period, the expected cases of new confirmed COVID-19 cases increased by 5 cases (EC=4.852, p<0.001, 95% CI: 3.895-6.043) compared to the expected cases during the post-vaccination period. Similarly, for every one-person increase in the Kavango East and Omaheke regions, the expected cases of new confirmed COVID-19 cases increased by 3 cases (EC=2.686, p=0.030, 95% CI: 2.658-3.715) and (EC=2.687, p=0.034, 95% CI: 2.659-3.716) respectively, while for every one person increase in males, the expected cases of new confirmed COVID-19 cases increased by 3 cases (EC=2.753, p=0.013, 95% CI: 2.726-3.801).

	Expected Count (adjusted)	**P-value**	**95% Confidence Interval**
(Intercept)	85.165	<0.001*	63.709-113.940
Day of the Week			
Monday	2.875	0.665	2.230-3.707
Tuesday	2.289	0.179	1.780-2.942
Wednesday	2.420	0.368	1.879-3.118
Thursday	2.400	0.317	1.881-3.063
Saturday	2.714	0.991	2.121-3.474
Sunday	2.723	0.990	2.126-3.486
Friday (ref)			
National Events			
2020 Namibian local and regional elections	1.438	0.422	0.304-6.810
Easter celebration	3.471	0.547	1.568-7.684
Festive celebration	2.825	0.858	1.854-4.304
National lockdowns	1.073	<0.001*	0.854-1.349
Public holiday	3.473	0.418	1.920-6.283
	Expected Count (adjusted)	**P-value**	**95% Confidence Interval**
Start of school term 1	2.956	0.916	0.627-13.936
Start of school term 2	3.917	0.644	0.833-18.428
Start of school term 3	1.676	0.543	0.353-7.954
End of school term 1	4.772	0.479	1.006-22.631
End of school term 2	1.030	0.114	0.309-3.428
End of school term 3	3.344	0.712	1.111-10.061
None (Ref)			
Erongo	2.705	0.334	2.678-2.732
Hardap	2.708	0.461	2.680-2.736
//Karas	2.716	0.859	2.687-2.745
Kavango East	2.686	0.030*	2.658-3.715
Kavango West	2.712	0.855	2.650-2.776
Khomas	2.710	0.559	2.684-2.737
Kunene	2.714	0.774	2.684-2.744
Ohangwena	2.724	0.719	2.693-2.755
Omaheke	2.687	0.034*	2.659-3.716
Omusati	2.697	0.147	2.668-2.726
Oshana	2.710	0.582	2.683-2.738
Oshikoto	2.712	0.689	2.684-2.741
Otjozondjupa	2.711	0.622	2.682-2.740
Zambezi	2.706	0.451	2.673-2.739
Weather Season			
Autumn	2.243	0.182	1.692-2.974
Summer	1.862	0.002*	1.467-2.365
Winter	2.540	0.600	1.971-3.274
Spring (ref)			
New Female cases	2.723	0.766	2.695-2.751
New Male cases	2.753	0.013*	2.726-3.801
New recoveries	2.719	0.163	2.718-2.721
Vaccination Period			
Pre-vaccination	4.852	<0.001*	3.895-6.043
Post-vaccination (ref)			

Table 2: Output from the Fitted Negative Binomial Regression Model
** Significant at a 5% Level Of Significance (Ref) = Reference Category*

4. Discussion

In this study, the Negative Binomial regression (modelling) technique was used to examine the contributing factors of new confirmed COVID-19 cases in Namibia using data extracted from the Ministry of Health and Social Services (MOHSS) official Facebook page, Worldometer and WHO webpage.

From 13 March 2020 to 31 December 2021, a total of 146,491 new confirmed COVID-19 cases were recorded in Namibia, with a spike in new cases observed during the winter season in 2020 (June - August), followed by a decrease during September and November 2020, whereas cases spiked during the festive season period (December 2020-January 2021), followed by a decrease between February and May 2021. This may be due to the seasonal flu occurrence normally experienced during the winter season, with people more susceptible to these seasonal flu outbreaks, while (constant) exposure to cold weather can adversely affect a person's immune response, making it harder for the body to fight other infections. These findings are similar to those of Lin et al. (2022), where it was concluded that there was a significant and conditional negative relationship between temperature, relative humidity and the number of new confirmed cases. The decrease in new confirmed COVID-19 cases experienced during September and November 2020 is similar to the findings of Daniyal et al. (2020), who concluded that the COVID-19 mortality rate might decrease by the end of October 2020 due to low confirmed case observations. Similarly, Mbow et al. (2020), Guzman et al. (2021) and Mutevedzi et al. (2022) found a lower infection rate and fatality risk in Africa compared to other regions of the world due to the lower impact the pandemic had in Africa, with fewer cases and deaths reported compared to the rest of the world. Nevertheless, they highlighted the need for increased surveillance and testing in the region to accurately monitor the disease's impact, given the challenges that arose due to limited healthcare infrastructure and economic constraints.

Conversely, the spike in cases observed during the festive season period in Namibia can be linked to public gatherings such as wedding ceremonies, Christmas, end of year and New Year's bash ceremonies held without strict adherence to COVID-19 regulations such as social distancing and wearing a mask. This agrees with the sentiments made by Maragakis (2021), who highlighted that COVID-19 cases tend to rise in areas where fewer people are wearing masks and more people are gathering indoors to eat, drink, celebrate and socialize without physical/social distancing. From this study, it was revealed that from June 2021 until July 2021, new cases rapidly increased and increased tremendously in August 2021 but later increased during the early days of December 2021, with the Khomas region having the most reported confirmed COVID-19 cases, followed by the Erongo and Otjozondjupa regions. This can be due to higher population densities in these developed regions, as well as business hubs and social/public gatherings and attractions. This also concurs with Maragakis' (2021) inference that places where people live or work closely together, such as multigenerational households, long-term-care facilities and other types of businesses, tend to see more spread of the virus.

Furthermore, from the best fit Negative Binomial regression model, the factors contributing to new confirmed COVID-19 cases in the country were the national lockdowns, Kavango East and Omaheke regions, summer season, males and pre-vaccination period. This can be linked to the summer weather being too hot and dry, prompting people to believe in unproven theories that COVID-19 cannot survive in heavy sunlight and higher temperature environments, thus making them not strictly adhere to the COVID-19 regulations such as hand sanitization, social distancing and (proper) wearing of a mask. In addition, the pre-vaccination period (March 2020 to February 2021) was identified as a contributing factor, which is not surprising as the WHO-approved COVID-19 vaccines were only made available in the country from March 2021. This is similar to the findings made by Maragakis (2021) and Bollinger et al. (2022), where it was revealed that the arrival of authorized COVID-19 vaccines in December 2020 helped bring new COVID-19 infection levels back down in many areas of the United States through the spring of 2021 and concluded that vaccination, even among those who acquire infections, was very effective at preventing serious illness, hospitalization and death from COVID-19. Bollinger et al. (2022) further recommend the need to get vaccines into the arms of as many people as possible since the virus will likely get milder over time as people build up immunity to it. However, despite the availability of these free vaccines in the country from March 2021 and continual efforts put in place by WHO, MOHSS, Namibian government and non-governmental/aid organizations to encourage people to get vaccinated against this deadly virus, the number of reported cases drastically increased in the country after the arrival of the vaccines. This was mostly due to the majority of the population's defiance of getting vaccinated based on personal beliefs, traditional beliefs, misinformation around the COVID-19 vaccination and constant disbelief of the existence of COVID-19 in their communities while still disregarding several national lockdowns, restricted travelling and curfews enforced regionally and countrywide. This finding agrees with those made by Mbow et al. (2020), who concluded that containment measures were not fully respected in many countries in the African region due to factors such as socio-cultural aspects, environmental exposures and socio-economic challenges, among others.

Moreover, the male gender was also identified as a contributing factor, as men were more at risk of both developing the severe form of COVID-19 and mortality. This is related to the discovery of Daniyal et al. (2020), who analyzed deaths by gender across different countries and concluded that men were more susceptible to COVID-19 and mortality than women. This may be due to heart disease, blood pressure, and smoking habits, which are more prominent in men than in women, thereby making them more vulnerable to COVID-19 than women. The Kavango East and Omaheke regions were also identified as contributing factors due to the high old age (60 years and above) population densities, traditional beliefs, misinformation around vaccines and constant disbelief of COVID-19 existence in communities within these regions. These findings are similar to those made by Gupta et al. (2020), Hu et al. (2020), Lopez Bernal et al. (2021), Mbow et al. (38) and Zhou et al. (2020) where it was revealed that socio-demographic factors such as age and gender were associated with increased COVID-19 infection rates, with higher infection and incidence rates among older age groups and a higher risk for males. Gupta et al. (2020) further revealed that males had a higher risk of COVID-19 mortality compared to females, while Mbow et al. (2020) concluded that the majority of the COVID-19-associated deaths in Africa occurred in older people. However, more reliable age-stratified data are still needed to fully grasp the COVID-19 situation in Africa and allow appropriate measures to be taken.

5. Conclusions

Given that little is known about the contributing factors of new confirmed COVID-19 cases besides no masking, no sanitizing and no social distancing, this study found that weather season, national events, vaccination period, sex and region were significant contributors to new confirmed COVID-19 cases in Namibia. It is, therefore, recommended that MOHSS, together with governmental and non-governmental/aid organizations, use the findings of this study in their efforts to further curb the spread of the COVID-19 virus in the country, especially during the current wave of the virus as well as in the event of a potential outbreak of the sixth and/or seventh waves of the deadly virus. Furthermore, since the COVID-19 vaccines (such as the Pfizer and Moderna vaccines) have been scientifically proven to be safe and effective at preventing serious illness or death from the virus as well as stimulating a stronger immune response in the human body, getting vaccinated with the complete number of vaccine doses as well as booster shots can be made mandatory while not violating individual's human rights to choose. This can be achieved through incentives, health and awareness campaigns via in-person and media platforms, and constant engagements and collaborations with community-based organizations such as churches, traditional authorities, community leaders, local authorities and regional councils whenever the need arises. Also, the provision of comprehensive and coordinated information on the spread and consequences of the virus in all spoken languages in the country and mobile vaccination spots, especially within highly populated density areas per region, are strongly recommended. While outdoor gatherings are safer than indoor ones, particularly if indoor spaces are small and without outdoor air coming in, meeting outdoors is further encouraged as it vastly reduces the risk of airborne transmission. However, this should also be done in conjunction with wearing of (nose) masks, using hand sanitizers and maintaining social distancing, especially with a few confirmed cases being reported at hospitals in some regions in Namibia.

On 5 May 2023, the WHO declared that COVID-19 was no longer a public health emergency of international concern. However, compared to its first outbreak in 2019, as long as it spreads through the human population, its mutations will continue to happen, and there will still be more new variant outbreaks that will cause new surges in cases and deaths. Thus, just like the regular winter flu (caused by influenza viruses) changes over time, resulting in the need to get a new flu vaccine every year, individuals should opt for full vaccination and regular COVID-19 boosters since data have shown that being up to date on vaccines and boosters can provide excellent protection against serious illness, hospitalization and death from COVID-19. Also, the Namibian government can make COVID-19 vaccination a mandatory travelling requirement for entry into the country, just like how the yellow fever vaccination is mandatory for entry into yellow fever risk or endemic countries in Africa (such as Congo, Benin, Burkina Faso, Kenya, Liberia, Rwanda, Sierra Leone, Niger and Togo) and in South America (such as Venezuela, Bolivia, Brazil, Panama and Colombia). This is needed, especially now that over 7,000 new confirmed COVID-19 cases have been reported in Africa just last month (May 2023). Furthermore, even though COVID-19 has been declared a non-public health emergency of international concern, the worst thing any country's government can do now is to let down its guard, dismantle the prevention systems it has built and put in place, or send the message to its citizens that the virus is nothing to worry about anymore. Thus, the government should continue all of its efforts to prevent viral transmission of COVID-19 by practising safety precautions, vaccinating as many people as possible as soon as possible, and encouraging boosters among those who are eligible, especially with a few confirmed cases already being reported at hospitals in some regions in Namibia and in some regional countries such as Mauritius, Cape Verde and Zimbabwe which reported the highest number of new confirmed COVID-19 infection cases in Africa (5,227; 444; and 345 respectively) during the month of May 2023.

Moreover, given the limited variables to consider within the COVID-19 dataset, it is recommended that more socio-demographic and economic variables such as age, marital status, employment status, type of occupation, place of residence, type of household dwelling, number of household members, educational attainment and travelling history of each COVID-19 confirmed case as well as their health indicators such as underlining illnesses and current COVID-19 vaccination status should be captured per COVID-19 confirmed case by MOHSS within their COVID-19 database. These can further be considered in the exploration of factors that contribute to new confirmed COVID-19 cases in the country using advanced statistical modelling techniques in preparation for the prevention and control measures for the next wave of COVID-19 outbreaks in Namibia.

6. Some Limitations

Though much progress has been made in recording the daily numbers of confirmed COVID-19 cases in Namibia, a few potential limitations could be perceived in this study. To be precise, the data for socio-demographic variables such as age, place of origin, gender and travelling history for each confirmed COVID-19 case were inconsistent, which could have broadened this study. However, these inconsistent variables did not affect the quality and outcome of this study. Moreover, data were collected voluntarily from the members of the population. However, not the whole population was tested, and people mostly volunteered to get tested for COVID-19 when they were sick, showed some known symptoms of COVID-19, wanted to travel out of the country and visit countries that required a compulsory 72-hour COVID-19 negative test result upon entry. In addition, there might be a possibility of the exclusion of COVID-19 patients who opted for self-medication at home or sought medical assistance from non-health facilities such as traditional healers.

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10. Author Contributions

OO and MVW conceived and designed the review. MVW acquired the data, while OO conducted the data analysis interpretation of findings and prepared the first draft of the manuscript. OO and MVW made substantial contributions in critically revising the drafted manuscript for important intellectual content and gave final approval of the final draft of the manuscript to be published. The final version of the manuscript was read and approved by both authors.

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