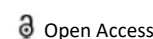




RESEARCH ARTICLE



Determinants that Associated with Traveling History of COVID-19 Patients in Ethiopia during Stay at Home State of Emergency

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ABSTRACT

Background: The recent outbreak of Novel Coronavirus (SARS-CoV-2) Disease (COVID-19) has put the world on alert and impacting societies around the world in an unprecedented manner. The main aims of this study was to investigate the association among the socio-demographic factors with traveling history of COVID-19 Patients in Ethiopia during stay at home state of emergency.

Methods: A total of 162 respondents with COVID-19 during March 13, 2020 to May 6, 2020 in Ethiopia were used. Two sided chi-square test was used to test the association between the socio demographic factors among COVID-19 Patients. A log-complement logistic regression model was used to compute the Health Ratios (HR) and 95% Confidence Interval (CI) to measure the effect of those factors.

Results: The data was analyzed using 162 patients of severe acute respiratory syndrome corona virus-2. An association was found between traveling history of COVID-19 infected patients and Gender (male vs. female) (5.410, $p < 0.020$) and Age group (13.082, $p < 0.004$). Log-complement logistic regression model showed that Gender and Age were significant factors associated to traveling history of COVID-19 Patients. Health ratio showed that increasing risk of traveling history for COVID-19 patients associated with higher number of males (HR=0.5895, 95%CI: 0.4007-0.8672, $P < 0.0073$) and Age group 18-39 years (HR=0.4139, 95%CI: 0.2385-0.7184, $P < 0.0017$) on patients of COVID-19. Akaike information criteria with minimum value (AIC=1.2158) indicated that Log complement logistic regression model was fitted the data well for the similar dataset of patients' with novel corona virus.

Conclusions: Male Gender and Age group 18-39 years are significant socio-demographic factors associated to traveling history of patients with corona virus disease. Further socio-demographic investigations are required to better understand the extent of association with Gender and Age for effective intervention and fight this pandemic to preserve lives.

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Introduction

Mankind has observed various pandemics throughout the history like the Middle East respiratory syndrome and severe acute respiratory syndrome. Now we are observing a very tough time once again fighting novel COVID-19 coronavirus [1,2].

Novel COVID-19 coronavirus are highly pathogenic and large-scale epidemic coronavirus into the human population in the twenty-first century. Outbreak of the COVID-19 started with the report of a first suspected case on December 8, 2019 in Wuhan, China. Due to the sudden outbreak of the COVID-19, China's health system is being verified for its effectiveness in responses.

Although the outbreak has brought huge socioeconomic loss, the public health system for emergency events in China will be undoubtedly much improved in the near future. Moreover, public reporting has become an accumulative advantage for China to collaborate with the WHO and other countries [3]. The occurrence of this epidemic may follow a nonlinear, chaotic and catastrophic process, rather similar to the epidemic of SARS that occurred in Hong Kong in 2003 [1].

Based on the latest WHO report, the number of infected people (over 1518719 globally, updated on 9 April 2020) and 88502 deaths. World Health Organization (WHO) declares to be effect in whole world wide to minimize spread of corona virus. Public health and social mea-

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asures are measures or actions by individuals, institutions, communities, local and national governments and international bodies to slow or stop the spread of COVID-19. These measures to reduce transmission of COVID-19 include individual and environmental measures, detecting and isolating cases, contact-tracing and quarantine, social and physical distancing measures including for mass gatherings, international travel measures, and vaccines and treatments. While vaccines and specific medications are not yet available for COVID-19, other public health and social measures play an essential role in reducing the number of infections and saving lives. Social and physical distancing measures aim to slow the spread of disease by stopping chains of transmission of COVID-19 and preventing new ones from appearing [4].

Corona virus case started with the report of first suspected case on March 13, 2020 in Addis Ababa. The case, which was announced on the 13th march 2020, is the first one to be reported in Ethiopia since the beginning of the outbreak in china in December 2019.

To focus on containment in the narrowing window of available time, WHO, in collaboration with Ethiopian Public Health Institute (EPHI), immediately started working to identify the contacts of the patient, from the patient entered in Ethiopia to the time of diagnosis of this first case. Human-to-human transmission of COVID-2 occurs mainly between family members, including relatives and friends who intimately contacted with patients or incubation carriers.

Some studies have been done on the comprehensive outbreak of corona virus that swept the world wide and highly contagious in human to human transmission affinity in this twenty first century. A recent researcher suggested that the virus primarily spreads through the respiratory tract, by droplets, respiratory secretions, and direct contact with a low infective dose 3-5. Huang study revealed that 49% of people who died of COVID-19 were aged 25-49 years, 34% were aged 50-64 years, and 17% were aged 65 years and above [6].

COVID-19 Related studies conducted in China and other states have focused mainly on the epidemiologic and clinical characteristics disease infectious [2-8], the Clinical features of patients with COVID-19 [6], the reasons of transmission [3-10] and symptoms and associated factors [3-10]. Evidence form the aforementioned studies in china was highly versatile and the results are inconclusive as the outbreak source is elusive. Even in Ethiopia, no study has yet focused on the novel corona virus seizure since there is scarcity of reliable and documented evidence on the prevalence rate among gender disparity in the country. Therefore, the current study to study the prevalence rate among gender disparity in confirmed cases of novel corona virus patients. The study will provide up-to-date

grounds for public health institute and the physician's for their appropriate intervention during quarantine period.

Materials and Methods

A retrospective analysis was conducted on the confirmed cases of COVID-19 admitted to Yeka Referral Hospital in Addis Ababa, Ethiopia from March 13, 2020 to May 6, 2020. Data for this study were obtained from daily cumulative and official reports of the Ethiopian ministry of health institute cases with novel corona virus infections for the first 55 days of pandemic outbreak. A total of 162 patients with COVID-19 infection were inscribed. Considering the scarcity of information and no monumental control measures were in place during this period, these data were used as the basis to predict the underlying epidemic, considering the overall epidemic. To predict the rate of change and modeled the traveling history of patient with associated demographically factors bivariate logistic regression was employed.

Statistical data analysis

Data were entered into STATA Version 14 for cleaning and analysis. Data cleaning was done by running frequencies, cross-tabulation and sorting among reported cases or variables. We did a descriptive analysis of the general characteristic of the patients at baseline of socio-demographic characteristics of the gender, travel history and age at infected with disease. The researcher employed the univariable analysis to study the relationship between dependent variable and each of independent variables by a univariable of binary logistic regression model. The association between categories of qualitative variables was carried out by chi-square of independence. The study use maximum likelihood parameter estimation using link function of logit link, log-complement link, log link and identity link were corresponding to odds ratio, health ratios, and risk ratio and risk differences respectively. Model comparison has been done using Akaike information criteria and Bayesian information criteria to select appropriate model with corresponding link function.

Dichotomous logistic regression model

Usually, binary data result from a nonlinear relationship between $\pi(x)$ and x . A fixed change in x often has less impact when $\pi(x)$. It is near 0 or 1 than when $\pi(x)$ is near 0.5 [11].

To obtain the model from the logistic function, z is expressed as a function (mostly linear function) of the explanatory variable using link function. Let Y_i =traveling history where $Y_i=0$ if the confirmed patient was stay in the country and $Y_i=1$ if the confirmed patient was travel somewhere and x_i is an explanatory variables with design levels for $i=0, 1, \dots, k$. That is, $Z_i=g(x_i)=\alpha + \beta x_i$.

The relationship between the response variable (proba-

bility of success) and the explanatory variable is not linear. This can be linearized by natural logarithms to the ratio of probability of the successes to probability of failure which is called logit transformation. The logit model is monotone depending on the sign of β . Its sign determines whether the probability of success is increasing or decreasing when the value of the explanatory variable increases. The parameters of the logit model can be interpreted in terms of odds ratios.

From logit $\pi(x_i) = \alpha + \beta x_i$, an odds is an exponential function of x_i . This provides a basic interpretation for the magnitude of β . The odds at x_i is $\Omega(x_i) = \exp(\alpha + \beta x_i)$ and the odds at $x_i + 1$ is $\Omega(x_i + 1) = \exp(\alpha + \beta(x_i + 1))$. Thus, the odds ratio will be $\exp(\beta)$.

This value is the multiplicative effect of the odds of successes due to a unit change in the explanatory variable. That is, for every one unit increase in x_i , the odds changes by a factor of $\exp(\beta)$. Similarly, for an m unit's increase in x_i , say $x_i + m$ versus x_i , the corresponding odds ratio becomes $\exp(m\beta)$. Also the parameter β determines the slope (rate of change or marginal effect) of the probability of success at a certain value of the explanatory variable. This rate of change (marginal effect) at a particular x_i value is described by drawing a straight line tangent to the curve at that point.

Multiple bivariate models for epidemic case

Suppose there are k explanatory variables (categorical, continuous or both) to be considered simultaneously. To obtain the multiple logistic regression models, in the logistic function, z should be expressed as a function (mostly linear sum) of the explanatory variables: $z_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik}$. Consequently, the logistic probability of success for subject i given the values of the explanatory variables $x_i = (x_{i1}, x_{i2}, \dots, x_{ik})$.

In this manner also $\exp(\beta_j)$ represents the odds ratio associated with an exposure if x_j is binary (exposed $x_{ij} = 1$ versus $x_{ij} = 0$) and it is the odds ratio due to a unit increase if x_j

is continuous ($x_{ij} = x_{ij} + 1$ versus $x_{ij} = x_{ij}$).

Results

Socio-demographic characteristics presentations

This study revealed that socio-demographic association of Age, Gender with traveling history of novel corona virus disease (COVID-19) patients during stay at home policy in Ethiopia. As of 6 May 2020, a total of 162 confirmed cases were reported, of whom 108 (66.67%) patients were having traveling history rather than stay at home. Among the 162 patients, there were 25 (15.43%) of females and 83 (51.23) males who had traveling history from the COVID-19 patients of confirmed cases. This study suggested that Gender was significantly associated with patients who had traveling history in spreading of novel corona virus as indicated in Table 1.

Male patients were significantly higher proportion in having traveling history than female patients (51.23% versus 15.43%, $\chi^2 = 5.410$, $p = 0.020$) at 5% level of significance. This implies there is association/dependence between gender and traveling history of patients with novel corona virus disease.

The patients in Age group 18-39 years (47.53%) had a significantly highest proportion of traveling history than other Age groups of COVID-19 Patients Table 1. As a result, 2.47% proportion of oldest (≥ 65 years) patients hadn't traveling history which is the lowest proportion as compared to other Age groups who stayed at home during policy of stay at home of novel corona virus disease. There was no significant proportion difference in Age between the two groups, namely; 0-17 and ≥ 65 years patients whom had traveling history. For pairs of two categorical variables, a two sided chi-square test was applied. There is a significant association between Age group and traveling history of patients ($\chi^2 = 13.082$, $p = 0.004$). The result of figure 1 showed that most of patients with COVID-19 were in Age group of 18-39 years 100(61.73%).

Table 1. Characteristics of socio-demographic variables of COVID-19 Patients during stay at home policy in Ethiopia and their association.

Items	Total (n=162)	Have traveling History (n=108)	Stay at home (n=54)	Statistics	P
Gender Female	47(29.01)	25(15.43)	22(13.58)	5.410	0.020
Male	115(70.99)	83(51.23)	32(19.75)		
Age Group 0-17	12(7.41)	5(3.09)	7(4.32)	13.082	0.004
18-39	100(61.73)	77(47.53)	23(14.20)		
40-64	41(25.31)	21(12.96)	20(12.35)		
≥ 65	9(5.56)	5(3.09)	4(2.47)		

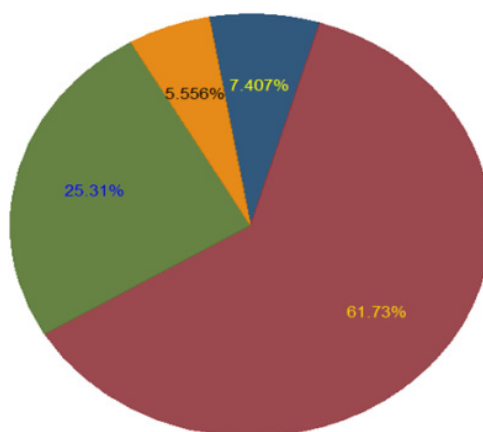


Figure 1. Graphical presentation of Age group distribution for confirmed cases of novel corona virus disease in Ethiopia. **Note:** (■) 0-17, (■) 18-39, (■) 40-64, (■) >=65.

Cross tabulation of gender, age group and traveling history

Chi-square test of association was done for categorical variables and the assumption of chi-square test also checked using cross-tabulation having count and expected count. The assumption of chi-square test said to be violated or not satisfied if the expected count of one or more cells were less than 5. As indicated in Table 2, the expected count of Age groups 0-17 and >=65 years crossed with stay at home were less than 5, which implies about 25% of expected count in those Age groups had less than five. The patients whose Age groups were 0-17 and >=65

years who stayed at home had expected count four and three respectively in this study.

Based on this, the assumption of chi-square test was violated. It is better to use either merging the lowest value of frequency to the nearest groups and again do analysis or applying another statistical tests to confirm/support the conclusions. A2 cells (25%) have expected count less than 5. The minimum expected count is 3.00.

As showed in the figure 2 of the bar-graph, the patients whose Age group was in 18-39 years had highest frequency in which they are participated on traveling activities during stay at home policy.

Table 2. Cross tabulation of Socio-demographic variables with traveling history of COVID-19 Patients for confirmed cases.

	Traveling history		Total
	Stay at home	Have traveling history	
Gender female count	22	25	47
Expected count	15.7	31.3	47.0
Male count	32	83	115
Expected count	38.3	76.7	115.0
Age group 0-17 count	7	5	12
Expected count	4.0	8.0	12.0
18-39 count	23	77	100
Expected count	33.3	66.7	100.0
40-64 count	20	21	41
Expected count	13.7	27.3	41.0
>=65 count	4	5	9
Expected count	3.0	6.0	9.0

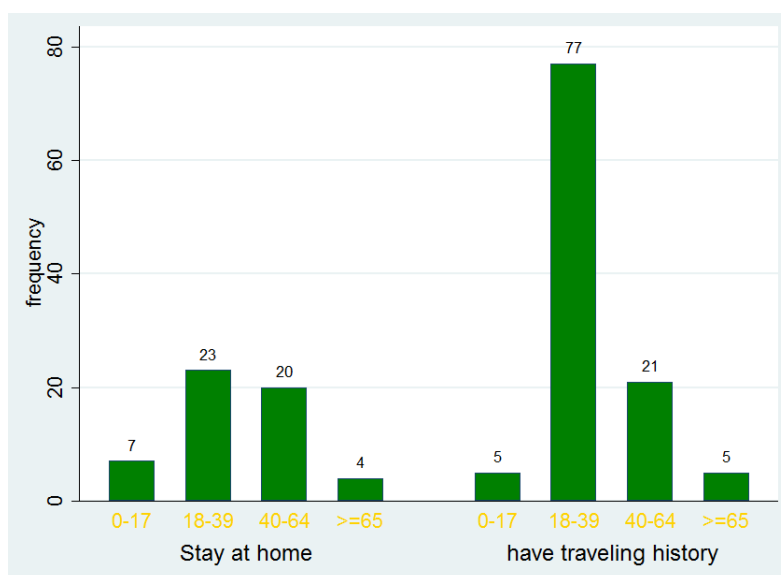


Figure 2. Distribution of Age groups for corona virus disease patients with traveling history.

Statistical model comparisons and selection for novel corona virus disease (covid-19) patients’ data set (n=162)

The Maximum likelihood Parameter estimation using link function of logit link, log-complement link, log link and identity link were corresponding to odds ratio, health ratios, and risk ratio and risk differences respectively. The binary logistic regression with those link functions and model comparison have been done using Akaike information criteria and Bayesian information criteria to select appropriate model with corresponding link function. As a result showed in Table 3, binary model with log-complement link function had smallest AIC (1.2158) and BIC (-611.7858) values as compared to other link functions. Therefore, logistic regression model with log-complement link function was an appropriate model to fit the dataset of patients in novel corona virus disease (COVID-19) considering socio-demographic factors. Log-complement link revealed that health ratios of patients that belongs to certain specific group. The estimated parameter for logistic model with log complement link of Health Ratios (HR) were 0.5895 (0.4007-0.8672) for male and 0.4139 (0.2385-0.7184) for patients whose Age group in 18-39 years as presented in Table 3.

Multivariate logistic analysis of the result and final model presentations on COVID-19 patients’ dataset

In the previous part (Table 2), four link functions with binary logistic models were fitted and compared to analyze the association between socio-demographic factors and traveling history of Novel corona virus disease patients’ during stay at home state emergency of Ethiopia. To model this relationship logit, log-complement, log and identity link functions with logistic model were applied and multivariate logistic with log-complement have

minimum Akaike information criteria (AIC=1.2158) and Bayesian information criteria (BIC= -611.7858) which is smaller than other candidates models. This suggested that binary logistic with log-complement model is more efficient model to describe the socio-demographic factors of COVID-19 Patients’ dataset.

The log-complement logistic regression was fit to the data as presented in Table 4. The 93% confidence intervals of the health ratios for all significant categorical variables do not include one at 5% level of significance. This indicated that they are significant socio-demographic factors that determining the traveling history of novel corona virus disease (COVID-19) Patients in Ethiopia. The health ratio for males who had traveling history was 0.5945 with 95% confidence interval (0.3892-0.9081) in univariate analysis.

The exponentiation negative health ratio for gender is $\exp(-0.5945)=0.5518$ (95%CI: 0.4033-0.6776). This is the inverse of risk in log complement transform for gender, which implies the probability of being stayed at home for males COVID-19 patient is 0.5518 fold that of the females’ patient probability that had stayed at home. In addition to this, the health ratio from multivariate logistic regression for gender who had traveling history was 0.5895 with 95% CI (0.4007-0.8672) and the risk in log-complement is $\exp(-0.5895)=0.5546$ (95%CI: 0.4201-0.6699) which connote that the Probability of being stayed at home for male patients is 0.5546 times that of the patients probability stayed at home for females. Similarly, the risk in log complement for Age group 18-39 is $\exp(-0.4139)=0.6611$ (95% CI: 0.4875-0.7878) which implies that the probability of being stay at home for patients whose Age group in 18-39 years is 0.6611 fold that of the patients probability stayed at home in Age group 0-17 years, keeping other factors constant.

Table 3. Parameter Estimation and appropriate model selection with link functions for COVID-19 data set.

Variables	OR(95% CI)	HR(95% CI)	RR(95% CI)	RD(95% CI)
Gender (male)	2.1850[1.0460-4.5645]	0.5895[0.4007-0.8672]	1.2020[0.8985-1.8060]	0.1540[-0.0167-0.3247]
Age group 18-39	4.3373[1.2306-15.2872]	0.4139[0.2385-0.7184]	1.7321[0.8755-3.4268]	0.3269[0.0278-0.6260]
40-64	1.3505[0.3590-5.0806]	0.9024[0.5433-1.4989]	1.1995[0.5780-2.4892]	0.0825[-0.2435-0.4086]
>=65	1.8270[0.3087-10.8145]	0.7995[0.3580-1.7854]	1.3743[0.5687-3.3214]	0.1571[-0.2890-0.6033]
Appropriate Model comparison and selection among logit, complement, log and identity link functions				
Log-Likelihood	-94.5140	-93.4834	-95.7385	-95.0270
AIC	1.2286	1.2158	1.2437	1.2349
BIC	-609.7246	-611.7858	-607.2756	-608.6987
Note: OR: Odds Ratio for Logit Link; HR: Health Ratios for Log Complement Link; RR: Risk Ratios for Log Link; RD: Risk Differences for Identity Link; AIC: Akaike Information Criteria; BIC: Bayesian Information Criteria.				

Table 4. Parameter Estimation and appropriate model selection with link functions for COVID-19 data set.

Variables	Univariate Analysis				Multivariate Analysis			
	HR	SE	95% CI for HR	P	HR	SE	95% CI for HR	P
Gender(male)	0.5945	0.1285	0.3892-0.9081	0.02161	0.5895	0.1161	0.4007-0.8672	0.0073
Age 18-39	0.3943	0.1202	0.2169-0.7168	0.0023	0.4139	0.1164	0.2385-0.7184	0.0017
40-64	0.8362	0.2440	0.4720-1.4815	0.5399	0.9024	0.2336	0.5433-1.4989	0.6917
>=65	0.7619	0.3394	0.3182-1.8241	0.5415	0.7995	0.3277	0.3580-1.7854	0.5851
Note: HR: Health Ratios; CI: Confidence Interval; SE: Standard Error.								

Discussion

Mankind has observed various pandemics throughout the history where some of them were more disastrous than the others to the humans. Severe Acute Respiratory syndrome corona virus-2 (SARS-COV-2) was first identified in China Wuhan city, by the Chinese Center for Disease Control and prevention (CDC) and now fastly spreading around the world. The disease is highly contagious pathogen found in severe domestic animals, pets and humans causing a different acute and chronic disease [12]. The current study aimed to investigate the association between socio-demographic variables for the novel corona virus disease patients during stay at home of emergency state in Ethiopia. A total of 162 persons with COVID-19 during March 13, 2020 to May 6, 2020 were included in this study. Chi-square test of association and logistic analysis with log complement link function were applied. The model comparison have been done by AIC and BIC and log-complement logistic regression which have smallest

Akaike Information Criteria (AIC=1.2158) and Bayesian Information Criteria (BIC= -611.7858) was the best fit of the novel corona virus disease patients' dataset.

This study revealed that there is strong association between gender, Age and traveling history of novel corona virus disease patients at 5% level of significance.

A two tailed chi-square test indicated that there is an association gender of patients and traveling history ($\chi^2=5.410$, $p<0.020$) in-lined with this, health ratio of log complement multivariate logistic analysis result for gender being male showed that there is a significant effect they had on the traveling history of respondent with severe acute respiratory syndrome corona virus-2(SARS-COV-2). The result from Table 3, Suggested that the health ratio for male is 0.5895 (95% CI: 0.4007-0.8672, $P=0.0073$) associated with traveling history of patients. Similar study conducted in Spain concluded that COVID-19 is highly influenced by age and gender with higher rates in older ages and males [13]. Another study in mainland China revealed that more

attention should be paid to male patients, especially those over 30 years of age, for enhanced clinical management [14]. The study conducted by Goujon suggested that the observed gender differences point at the need to pay special attention to health care workers regardless whether they are male or female [15]. Other studies consistent with this were [16-19].

Patients in Age group 18-39 years is 100 (61.72%) higher than other Age groups of patients with COVID-19 as indicated in Table 1. There was a significant association between traveling history of COVID-19 Patients and Age group. According to this study, patients traveling history and Age have strong relationships ($\chi^2=13.082$, $p<0.004$) at 5% level of significance. The estimated log-complement logistic regression model showed that Age group 18-39 years of patients has significant effect on the traveling history of patients with COVID-19 patients during stay at home policy. An estimated health ratio is 0.3943 (95%CI: 0.2169-0.7168, $P<0.0023$) for univariate analysis and 0.4139 (95%CI: 0.2385-0.7184, $P<0.0017$) log-complement multivariate logistic analysis respectively. Study conducted by Liu W suggested that Age is significant factors associated to COVID-19 Patients ($p<0.001$) [20]. Result of study conducted in Spain confirmed that COVID-19 is highly influenced by age and gender with higher rates in older ages and males [13]. Another study consistent with the findings was identified that Age as risk factors for COVID-19 patients which analyzed using logistic regression analysis [21]. Several studies are confirmed with our findings [14-25].

Limitations

This study had some limitations. Some clinical and epidemiological risk factors could not be included due to data insufficiency. The missing data were unavoidable as we did a retrospective study. Considering that the missing data were caused by non-human factors and many were from the same individuals, patients with missing data were not included in the subsequent analysis which means we restricted the analysis to individuals without missing data.

Conclusion

This study investigated the Socio-demographic factors association with traveling history of COVID-19 patients and selection of its prediction models. It is very essential for planning health resources and the design of moderation policies, including intelligent strategies to release population from confinement while protecting the most vulnerable. In this study, we estimated the health ratios of Gender and Age group associated to Traveling history of patients that have higher risk ratio for males and Age group 18-39 years. Log complement logistic regression model was the best that fits the COVID-19 patients' dataset and used for

predictions. Public health and social measures to slow or stop the spread of COVID-19 must be implemented with the full engagement of all members of society. The Ethiopian Authorities and Government should be launched psychological treatment, and we truly despair that Ethiopian people and other countries get the better of the epidemic as fast as possible.

Authors' contributions

KKG and MWD conceived this Article, performed the literature review and wrote the paper; all authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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