MODELLING CORONAVIRUS MORTALITY AND IMPLICATIONS ON POPULATION DYNAMICS IN THE ABSENCE OF VACCINATION

BY

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BACKGROUND AND STATEMENT OF THE RESEARCH PROBLEM

- Population dynamics deal with population change and the direct drivers are fertility (births), mortality (deaths) and migration.
- The WHO declared coronavirus (COVID-19) a pandemic on 11 March 2020.
- COVID-19 continues to be a deadly disease for some people as there is still no cure though large scale rollout of COVID-19 vaccines has commenced in several countries.
- According to the WHO figures there were 58,968,188 confirmed cases of COVID-19 globally and 1,387,647 cumulative COVID-19 deaths globally as at 16 November 2020. This was before rollout of COVID-19 vaccines in any country.
- The reported global figures of COVID-19 cases and fatalities most probably underestimate the magnitude of the pandemic, as coverage and efficiency in screening and testing for COVID-19 vary from country to country.

BACKGROUND AND STATEMENT OF THE RESEARCH PROBLEM(CONTD).

- Vital registration is limited or non-existent in some countries. In some, a death certificate is not required before burial. In these circumstances, statistics on COVID-19 deaths may not accurately reflect the true picture.
- Many countries adopted a monitoring strategy in the progression of COVID-19 by reporting and publishing statistical figures regarding COVID-19 daily.
- Inappropriate interpretation of these official figures could misinform decision makers in the private and public sectors and consequently undermine effective intervention and management of COVID-19.
- It is important therefore that researchers provide critical examination and interpretation of the official COVID-19 figures to guide policy in the management of the pandemic.

RESEARCH OBJECTIVES.

- Using COVID-19 data from South Africa, this author

1. Assessed the progression in cumulative COVID-19 case fatality rates i.e., a critical examination of COVID-19 fatality from official data in the absence of vaccination.
2. Draws attention to the implications of COVID-19 fatality on population dynamics in the absence of vaccination.

- Objective 1 provides a context for objective 2.
- The modelling using South African data can be applied to any country that has COVID-19 data.

DATA AND LIMITATIONS.

- Daily numbers of confirmed cases of COVID-19, number deceased and total number of persons tested, as published in the Media Release statements by South Africa's Minister of Health.
- These numbers were captured in an EXCEL spreadsheet by the author in a manner amenable to analysis. For example, figures for Day 73 from the start of the pandemic has a reference date of 16 May 2020; being seventy-three days from the date of the first confirmed case (5 March 2020) of COVID-19 in South Africa.

DATA AND LIMITATIONS (CONTD).

- Limitations of the data include:

1. Coverage: Coverage of testing for COVID-19 was still extremely low at the time of the study. As at day 200 since the start of the pandemic (20 September 2020), the reported number of persons tested was 4,041,543 nationally. This constituted only about 7% of the estimated mid-2020 total population of South Africa (see Udjo, 2020 for the population estimates). As at 22 June 2021, the number of persons tested was 12,633,235 i.e. about 22% of the estimated mid-2020 total population.
2. Representativeness: It is debatable whether the persons tested for COVID-19 are a representative sample of South Africa's population. Persons tested may have been predominantly those who showed symptoms, or who had been in close contact with persons who showed symptoms of COVID-19. It is possible therefore, that these may be biased towards persons in the high-risk categories and their contacts.

- The limitations should be borne in mind in the interpretation of the results.

METHODS.

Progression in COVID-19 Case Fatality and Estimating the Number of Deaths from COVID-19

- This is a difficult subject as the reported number of COVID-19 related deaths may be influenced by several factors.
- I employed a-two stage approach: firstly, estimating cumulative crude case fatality rates and secondly, estimating the number of COVID-19 case fatalities.

METHODS (CONTD).

Cumulative Crude Case Fatality Rates.

- This refers to the cumulative number of deaths that are COVID-19 related per thousand confirmed COVID-19 cases and computed as

$$\boldsymbol{CumCFatRateCOVID19^t = (CumDeathCOVID19^t / CumCOVID19^t) * k} \quad \text{.....(1)}$$

Where $CumCFatRateCOVID19^t$ is the cumulative crude case fatality rate from COVID-19 as at a specified time, $\boldsymbol{CumDeathCOVID19^t}$ is the cumulative number of COVID-19 deaths among the cumulative number of those testing positive as at a specified time, $\boldsymbol{CumCOVID19^t}$ is the cumulative number of confirmed COVID-19 cases among the cumulative number of tests conducted as at the specified time, *k* is a constant set at 1,000.

METHODS (CONTD).

Estimating the Number of Deaths from COVID-19 (contd)

- The number of COVID-19 deaths as at a specified date in the general population was then estimated as.

$$EDeathCumCOVID19^{t} = (MidCumFatRateCOVID19^{t}/1000) * COVID19^{m}_{dn} \quad \ldots\ldots\ldots \quad (2)$$

Where $EDeathCumCOVID19^{t}$ is the estimated Cumulative number of COVID-19 deaths in the population as at a specified time, $\boldsymbol{MidCumFatRateCOVID19^{t}}$ is the estimated mid-year crude fatality rate due to COVID-19, $\boldsymbol{COVID19^{m}_{dn}}$ is the model estimate of the number of cumulative COVID-19 infections as at a specified date. The estimation of $\boldsymbol{COVID19^{m}_{dn}}$ is not shown here but can be found in another study by this author.

METHODS (CONTD).

Estimating the Number of Deaths from COVID-19 (contd)

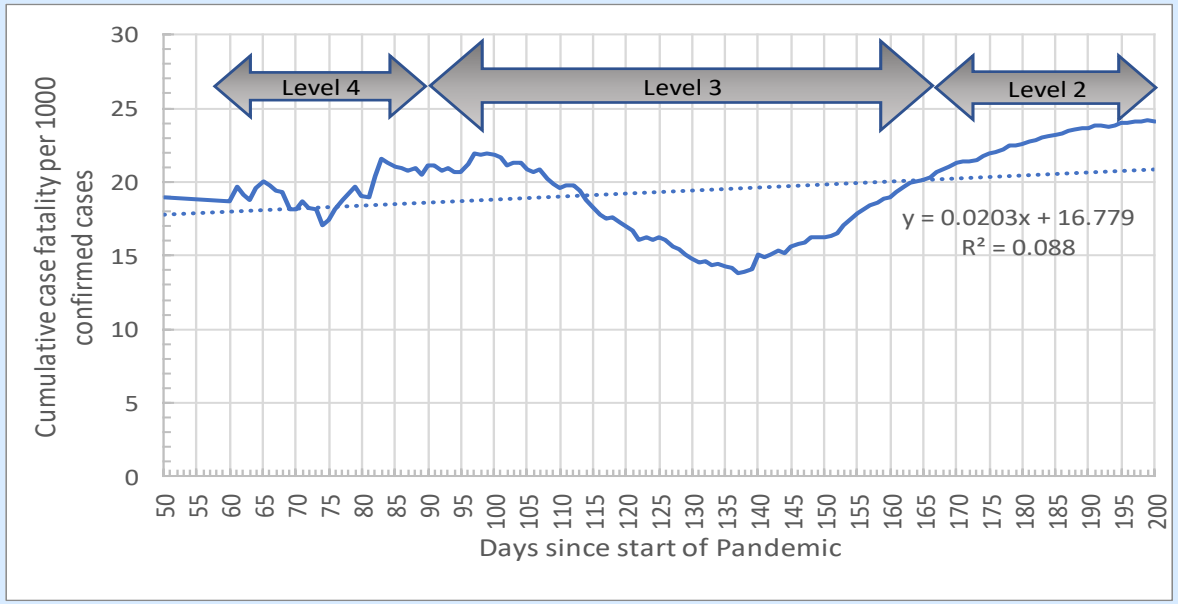
- The values of $CumCFatRateCOVID19^{t}$ began to stabilise from day 48 onwards during the now so called first wave of COVID-19 among those testing positive.
- A scatter plot of the values of $CumCFatRateCOVID19^{t}$ was therefore made from day 50 onwards.
- The intercept, a, and slope, b of these values, were then estimated by fitting a straight line by least squares to the values.
- Using these constants, the cumulative crude fatality rates were projected to mid-2020.

RESULTS.

Progression in Cumulative COVID-19 Case Fatality Rates

Puzzling why the cumulative death rates declined during the period 105-138 days. Could be underreporting of COVID-19 related deaths during the period.

- The coefficients of the fitted line indicate an average of 17 COVID-19 deaths daily per thousand confirmed COVID-19 cases during the later part of lockdown level 5 and end of lockdown level 2.



RESULTS (CONTD).

Comparison of Official and Model Cumulative Crude Death Rates from COVID-19

- The differences appear to suggest that the official figures understated the magnitudes of cumulative numbers of COVID-19 related deaths at different points in time

		Cumulative Numbers of COVID-19 deaths		
Lockdown Level	Date	Official	Model*	Difference*
4	15/5/2020	247	385	138
4	29/5/2020	611	828	217
3	15/6/2020	1,568	2,117	549
3	29/6/2020	2,529	4,175	1,646
2	1/9/2020	14,263	18,950	4,687
2	15/9/2020	15,641	19,476	3,835

*Source: Author's estimation

IMPLICATIONS OF MAGNITUDES OF COVID-19 FATALITIES ON POPULATION DYNAMICS

- Cannot be business as usual with COVID_19 on demographic/population estimation. Need to modify approach in modelling demographic/population parameters.
- **Childhood Mortality: Indirect methods** often based on children surviving of children ever born in the absence of vital registration data. The time location or reference period of the estimates usually about 1.5 - 17 years before the survey/census. Estimates of infant mortality & under five mortality will therefore not capture COVID-19 fatality since the time location indicate the deaths were pre-covid period. Using the traditional indirect approach will no doubt underestimate childhood mortality unless for surveys/census carried out after 2021. Even then, indirect methods will only capture infant mortality that includes COVID-19 related deaths. **Direct Methods** utilise birth histories. Reference period of estimates from birth histories usually questionable. Life tables from birth histories collected prior to 2021 will certainly underestimate infant and under five mortality since they will not capture COVID-19 fatalities.

IMPLICATIONS OF MAGNITUDES OF COVID-19 MORTALITY ON POPULATION DYNAMICS (CONTD)

- **Adult Mortality based on Orhphanhood**: Similar situation as in indirect estimation of childhood mortality. Because the time location of adult male and female mortality usually ranges between 5-17 years before the survey/census, the estimates will not capture COVID-19 fatality among adults. But orphanhood data collected in 2025 onwards will capture some COVID-19 fatalities but this will only be for adults roughly between the ages of 15 and 20.
- **Mortality from deaths in households:** Reference period for the questions (no of deaths in the household by age & sex) is usually 12 – 24 months before the census/survey. Surveys/censuses implemented from 2022 would capture some childhood and adult COVID-19 fatalities depending on the quality of the data. Data on household deaths collected before this date will not capture COVID-19 fatalities.
- **Vital Registration Data:** Some countries have fairly good vital registration data. The most current data for South Africa is for the year 2017. This data set will not capture COVID-19 fatalities for South Africa.

IMPLICATIONS OF MAGNITUDES OF COVID-19 MORTALITY ON POPULATION DYNAMICS (CONTD)

- **Fertility:** Some speculation that COVID-19 might lead to baby boom. Vital registration data currently not available at least, in South Africa to test this speculation. On the other side of the coin however, one may ask: given that some of the COVID-19 fatalities are women of reproductive age, what is the long term effect on gross and net reproduction rates and consequently on population growth in different countries? Modelling could be used to attempt to answer this question but some of such modelling are likely to paint a grim picture as was the case with HIV/AIDS in countries like Uganda and Kenya. We can only get empirical answer to this question after many years.

IMPLICATIONS OF MAGNITUDES OF COVID-19 MORTALITY ON POPULATION DYNAMICS (CONTD)

Population Projections

- In its most basic form, population projections are based on the so called basic demographic or balancing equation:

$$P_{(t+n)} = P_t + B_{(t,t+n)} - D_{(t,t+n)} + I_{(t,t+n)} - E_{(t,t+n)} \quad (3)$$

Re-writing the above equation, we get

$$P_{(t+n)} - P_t = B_{(t,t+n)} - D_{(t,t+n)} + I_{(t,t+n)} - E_{(t,t+n)} \quad (4)$$

The left side of equation (4) is population change, thus, population dynamics is a function of the elements in the right side of equation (4).

- The left side of the equation (3) is the projected population, the parameters in the right side of the equation (3) are respectively, the base population, births, deaths, immigration and emigration. The cohort component method of projection is an age-sex decomposition of equation (3).

IMPLICATIONS OF MAGNITUDES OF COVID-19 MORTALITY ON POPULATION DYNAMICS (CONTD)

Population Projections (contd)

- For the purpose of this presentation, let us focus on the $D_{(t,t+n)}$ parameter i.e. the mortality component. Usually this would be derived from life expectancy at birth based on mortality estimation using any of the methods described above. However, none of the model life tables currently in use for population projections captures COVID-19 mortality.
- COVID-19 mortality therefore needs to be factored in directly in any population projections. The first part of this presentation demonstrated how the magnitudes of COVID-19 fatality can be estimated. Further modelling of the estimated magnitudes would be required before incorporating these into projected populations.
- I would be highly suspicious mid-year population projections that do not directly factor in COVID-19 mortality.
- The short and long term implications of the migration components in equation (3) on population growth would primarily depend on long term policy measures adopted by various governments especially on immigration. We have seen some short term pronouncements on international travel in the context of COVID-19.

CONCLUSION

- Official figures of COVID-19 fatalities should be interpreted as indicative and not taken at face value as global and national figures most probably under represent COVID-19 deaths.
- COVID-19 mortality poses challenges to demographic/population estimation. Population scientists and training institutions need to re-think their approach in modelling demographic/population parameters in the context of COVID-19.
- Several countries prior to the COVID-19 pandemic produced short to medium term population projections. These projections need to be re-visited and revised in the light of COVID-19 to guide policy in effective allocation of scarce resources in various sectors of the economy.
- The rollout of COVID-19 vaccination makes modelling of COVID-19 on population dynamics even more complicated but should not be ignored.
- It is the duty of population scientists, demographic training institutions, statistical agencies to ensure that the demographic indicators they produce adequately reflect the demographic and epidemiological realities of the countries for which those estimates are made.

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The views expressed in this seminar however, are those of the author and not necessarily the views of the reviewers listed above.

THANK YOU. KEEP SAFE