Technical Appendix

Updated 6/2/2020

Part A. Mortality Indicators

<u>Section 1. Period Crude Covid-19 Death Rate (*CCDR*)</u>

1.1 Get estimate date & estimated number of covid-19 deaths by country/territory with at least one reported case by June 1, 2020 from the "Cases and mortality by country" table at: https://coronavirus.jhu.edu/data/mortality
    1.1.a Except for China, get estimate date & estimated number of covid-19 deaths for Hubei Province from "Total Deaths' box at: https://coronavirus.jhu.edu/map.html
    1.1.b Plus for US states, get estimate date & estimated number of covid-19 deaths by state from "Total deaths" graph at: https://covid19.healthdata.org/united-states-of-america/

1.2 Get projection end date & projected number of covid-19 deaths by country and territory (52 as of this writing) & U.S. states from the "Total Deaths" graph at: https://covid19.healthdata.org/

1.3 Get date of first CoViD-19 case and first CoViD-19 death from WHO situation reports (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports) and total mid-2020 population size for each of the countries/territories in (1.1) (see Part B for example)

1.4 Calculate first-case-to-date exposure in person-years for each country, territory, province & state (location thereafter) in (1.2) & (1.3) as:

$$N.T$$

where N is total population size in (1.3) & T is year-to-date duration in year converted from dates in (1.1) & (1.2), e.g., if date 8/4/2020, $T=(31+29+31+30+31+30+31+4)/366$

1.5 Calculate first-case-to-date Crude Covid-19 Death Rate (period *CCDR*) for each location in (1.1) & (1.2) as ratio of deaths in (1.1) & (1.2) to first-case-to-date exposure in (1.4)

<u>Section 2. Comparative Covid-19 Mortality Ratio (*CCMR*)</u>

2.1 Get report date and number of registered covid-19 deaths by sex and age group from: https://data.cdc.gov/NCHS/Provisional-COVID-19-Death-Counts-by-Sex-Age-and-S/9bhg-hcku

2.2 Get the mid-2020 population size by age groups, $_nN_x$, for each sex and the same age groups as in (2.1) for each location in (1.1) (see part B for example)

2.3 Calculate first-case-to-date age-and-sex-specific covid-19 death rates for the U.S.A. using the estimate date of first CoViD-19 case and estimated number of covid-19 deaths in the country in (1.1), the distribution of deaths by sex and age group in (2.1) and the mid-2020 population by sex and age group in the country in (2.2) as:

$$_nD_x^C / {_nN_x}.T$$

where (separately for males and females) $_nN_x$ is the the mid-2020 population in age group x to $x+n$ in (2.2), T is the duration of exposure in (1.3) & $_nD_x^C$ is the number of covid-19 deaths in (1.1) multiplied by the ratio of deaths in the age group to total deaths in (2.1)

2.4 Calculate estimated and projected counterfactual numbers of covid-19 deaths for each location in (1.1) using the sex and age-specific covid-19 death rates for the U.S.A. in (2.3) and the mid-2020 population by sex and age group in (2.2)

2.5 Calculate the Comparative Covid-19 Mortality Ratio (CCMR) for estimated and projected numbers of covid-19 deaths for each location in (1.1) as the ratio of the actual estimate in (1.1) or projected number in (1.2) to the corresponding counterfactual number in (2.4)

Section 3. Projected Reduction in 2020-Life Expectancies

3.1 Get period life-table age-specific death rates ($_nm_x$) and survival probabilities ($_np_x$) for year-2020 for each country in (1.1) (see Part B for example)

3.2 Calculate the age-specific ratio of updated to previously projected deaths from all causes in 2020 for each country in (1.1) as:

$$_nR_x = \frac{_nm_x \cdot \left(_nN_x - \left((1 - \overline{t_m}) \cdot _nD_x^C \right) \right) + _nD_x^C}{_nm_x \cdot _nN_x}$$

where $_nm_x$ is the age-specific death rate in the previously projected year-2020 life table from (3.1), $_nN_x$ is the mid-2020 population by age group from (2.2), $_nD_x^C$ is the projected number of covid-19 deaths in the age group obtained by multiplying the total for the Country in (1.2) by the ratio of deaths in the age group to total deaths in the U.S.A. in (2.1) & $\overline{t_m}$ is the fraction of a year corresponding to the average time of covid-19 deaths estimated here as the mid-point between the first CoViD-19 death in the country and the end date of the projection (August 4, 2020 as of this writing)

3.3 Calculate age-specific survival probabilities in the new projected year-2020 life table for each country in (1.1) from (3.1) & (3.2) using Chiang (1968) formula:

$$_n^*p_x = {_np_x}^{_nR_x}$$

3.4 Calculate the age-specific number of years lived after age x for individuals dying in the age interval in the new projected year-2020 life table for each country in (1.1) from its corresponding value in the previously projected year-2020 life table derived from (3.1) and the life table relationship:

$$_na_x = \frac{1}{_nm_x} - n \cdot \frac{_np_x}{1 - _np_x}$$

& from (3.2) and (3.3) using the Preston et al. (2001: 84) formula:

$$_n^*a_x = n + \left(_nR_x \cdot \frac{_nq_x}{_n^*q_x} \cdot \left(_na_x - n \right) \right)$$

and

$$^*a_{85+} = \frac{a_{85+}}{R_{85+}}$$

3.5 Calculate new values of life expectancies (e_x^o values) in the year-2020 life table for each country in (1.1) starting with $e_x^o = {^*a_{85+}}$ in (3.4) and then using values in (3.3) & (3.4) with the life table relationship:

$$e_x^o = {_np_x} \cdot (e_{x+n}^o + n) + {_na_x} \cdot (1 - {_np_x})$$

3.6 Calculate the difference between the new values of life expectancies in year-2020 life table for each country in (1.1) in (3.5) and the original values derived from values in (3.1) and the life table relationship:

$$e_x^o = \left({_np_x} \cdot e_{x+n}^o \right) + \frac{1}{_nm_x} \cdot \left(1 - {_np_x}\right)$$

Part B. Demographic Parameters

Section 1. Mid-2020 Population Size

1.1 (step 1.3 in part A) Total mid-2020 population size for each country and territory was obtained from the "Total Population" file at:
https://population.un.org/wpp/Download/Standard/Population/
1.1.a For provinces in China, population size was multiplied by the ratio of the 2019-year-end total population estimates for the Province divided by the corresponding estimates for the country obtained at:
http://data.stats.gov.cn
1.1.b For U.S. states, the size of each age group was multiplied by the ratio of the 2018-age-group sizes estimated for the state divided by the corresponding estimate for the country obtained at:
https://data.census.gov/cedsci/table?q=United%20States&g=0100000US&tid=ACSDP1Y2018.DP05&hidePreview=true&table=DP05
1.2 (step 2.2 in part A) Dates of first CoViD-19 case and death for countries, territories and provinces were retrieved from the World Health Organization's daily situation reports at https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/ For U.S. states, dates were obtained from the Institute for Health Metrics and Evaluation at https://covid19.healthdata.org.
1.3 (step 2.2. in part A) For countries and territories with a population size over 90,000,mid-2020 population size by age group was obtained from the "Population by Age and Sex" file at: https://population.un.org/wpp/Download/Standard/Population/
with the following adjustments:
1.3.a   Number of infants (under age 1) for each Country was obtained from the "Annual Population by Age – Both Sexes" file at:
https://population.un.org/wpp/Download/Standard/Interpolated/
1.3.b   Number in age group 1-4 for each Country was obtained as the difference between the number in the first age group (age 0-4) in the population by 5-year age groups above & the number of infants in (1.2) above
1.3.c   Numbers in age groups 5-14 to 75-84 for each Country were obtained by adding the numbers in two consecutive age groups (e.g., ages 5-14 & ages 15-24) in the population by 5-year age groups
1.3.d   Number in age group 85 and over for each Country was obtained by adding the numbers in the last four age groups (i.e., ages 85-89, 90-94, 95-99 & 100+) in the population by 5-year age groups

1.3.e   For provinces in China, population size in each group was multiplied by the ratio of the 2019-year-end total population estimates for the Province divided by the corresponding estimates for the country in (1.1.a) above

1.3.f   For U.S states the size of each age group in 2018-age-group was obtained at https://data.census.gov/cedsci/table?q=United%20States&g=0100000US&tid=ACSDP1Y 2018.DP05&hidePreview=true&table=DP05 and prorated to the 2020 population size in the UN data.

Section 2. Calendar-Year-2020 Period Life Table Values

2.1 (step 3.1 in part A) The period life-table age-specific survival probabilities ($_np_x$) for year-2020 for each country in (1.3) above are obtained from the corresponding values in the estimated 2015-20 & projected 2020-25 life tables in the "Life table survivors (lx) at exact age x - Both Sexes" file at:
https://population.un.org/wpp/Download/Standard/Mortality/

2.1.a   Age-specific survival probabilities ($_np_x$) in the estimated 2015-20 & projected 2020-25 life tables for each country in (1.3) above are obtained from the number of survivors by age (l_x) and the life table relationship:

$$_np_x = \frac{l_{x+n}}{l_x}$$

2.1.b   Period life-table age-specific survival probabilities ($_np_x$) for year-2020 for each country in (1.3) above are obtained as:

$$_np_x[2020] = \sqrt[2]{_np_x[2015-2020]. \ _np_x[2020-2025]}$$

2.2 (step 3.1 in part A) The period life-table age-specific death rates ($_nm_x$) for year-2020 for each country in (1.3) above are obtained from the corresponding values in the estimated 2015-20 & projected 2020-25 life tables in the "Life table survivors l(x) at exact age x" & "life expectancy at exact age x" files at:
https://population.un.org/wpp/Download/Standard/Mortality/

2.2.a   Age-specific death rates ($_nm_x$) in the estimated 2015-20 & projected 2020-25 life tables for each country in (1.3) above are obtained the male/female number of survivors by age (l_x) & the male/female life expectancy by age (e_x^o) and the life table relationships:

$$_nm_x = \frac{l_x - l_{x+n}}{(l_x.e_x^o) - (l_{x+n}.e_{x+n}^o)}$$

&

$$m_{x+} = \frac{1}{e_x^o}$$

2.2.b   Period life-table male/female age-specific death rates ($_nm_x$) and survival probabilities ($_np_x$) for year-2020 for each country in (1.3) above are obtained as:

$$_nm_x[2020] = (_nm_x[2015\text{-}20] + _nm_x[2020\text{-}25]) /2$$