Technical Appendix

Updated 5/25/2020

Part A. Mortality Indicators

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

1.1 Get estimate date & estimated number of covid-19 deaths by Country (Countries with >1,000 covid-19 deaths—15 as of this writing) 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 U.S. States (with >1,000 covid-19 deaths—9 as of this writing), 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 (European Countries with >1,000 covid-19 deaths—9 as of this writing—& the U.S.A.) & U.S. States (with >1,000 covid-19 deaths—9 as of this writing) from the "Total Deaths" graph at: https://covid19.healthdata.org/

1.3 Get date of first CoViD-19 death and total mid-2020 population size for each of the Countries in (1.1) (see Part B for example)

1.4 Calculate first-death-to-date exposure in person-years for each of the Countries, Province & States 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-Death-To-Date Crude Covid-19 Death Rate (FDTD CCDR) for Countries, Province & States in (1.1) & (1.2) as ratio of deaths in (1.1) & (1.2) to year-do-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 Country and State in (1.1) (see part B for example)

2.3 Calculate year-to-date age-and-sex-specific covid-19 death rates for the U.S.A. using the estimate date 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 number of covid-19 deaths for each Country, Province, and State 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 number of covid-19 deaths for each Country or Province 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 Change 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 average time of covid-19 deaths estimated here as the mid-point between January 1st, 2020 and the end date of the projection (e.g., with the end date of August 4, 2020 as of this writing, the value of $\overline{t_m}$ is ½. (31+29+31+30+31+30+31+4)/366)

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:

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

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 was obtained summing across age groups the population by 5-year age groups in the "Population by Age Groups – Both Sexes" file at:
https://population.un.org/wpp/Download/Standard/Population/
1.1.a For Hubei Province, population size was multiplied by the ratio of the 2018-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 in (1.1.b), 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 death for most Countries and States were retrieved from the Institute for Health Metrics and Evaluation at
https://covid19.healthdata.org. For other Countries, dates were obtained from the World Health Organization's daily situation reports at
https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/

1.3 (step 2.2. in part A) Mid-2020 population size by age group for each Country was obtained as follows:

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 in (1.1) 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 in (1.1)

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 in (1.1)

1.3.e   For Hubei Province, population size in each group was multiplied by the ratio of the 2018-year-end total population estimates for the Province divided by the corresponding estimates for the country in (1.1.a) above

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 (1.1) 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 (1.1) 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 (1.1) 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 (1.1) 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" & "Life expectancy at exact age x (ex)- Both Sexes" 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 (1.1) are obtained the number of survivors by age (l_x) & the 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 age-specific death rates ($_nm_x$) and survival probabilities ($_np_x$) for year-2020 for each Country in (1.1) are obtained as:
$$_nm_x[2020] = (_nm_x[2015\text{-}20] + _nm_x[2020\text{-}25]) /2$$