Estimated life expectancy impact of SARS-CoV-2 infection on the entire German population

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The life expectancy of the currently living German population is calculated per age and as weighted average. The same calculation is repeated after considering everyone infected with and potentially killed by SARS-CoV-2 within one year, given the current age-dependent lethality estimates from a study at London Imperial College [1]. For an average life expectancy of 83.0 years in the current population, the reduction due to SARS-CoV-2 infection amounts to 2.0 (1.1-3.9) months. The individual values show a maximum of 7.7 (4.4-15.2) months for a 70-year-old. People below age 50 loose less than 1 month in average.

I Motivation

Statistical numbers in the current pandemic help estimating the impact of SARS-CoV-2. Easily obtainable are *e. g.* (a) confirmed cases of COVID-19, (b) deaths with COVID-19, and the consequent case fatality ratio (CFR). However, especially (a) remains strongly biased as current testing is, due to limited resources and cost-benefit, mainly conducted on those with strong need. Those usually show an already severe stage of the disease, and/or posses a high risk due to old age (with 87% of COVID-19 deaths above 70) and pre-existing illnesses such as cardiac diseases, chronic liver/lung diseases, diabetes mellitus and cancer [2]. This inhomogeneous testing makes confirmed cases and thus the current CFR unsuitable for estimating the impact SARS-CoV-2 may have on the whole population.

In contrast, the actual lethality does not depend on testing bias. It is the relevant quantity to estimate the impact of SARS-CoV-2 and becomes available with additional information such as infection prevalence [1].

Chance of death however, and moreover 'prevented' deaths, can be misleading in the presence of other life threats. As death is for sure and can only occur prematurely, the main impact of risk factors and diseases is reduction of lifetime. Thus, the focus will be the average life expectancy loss due to SARS-CoV-2. Unlike epidemiologists who model the course of the disease, we quantify the worst case scenario *i. e.* everyone in the German population getting infected and potentially killed within one year.

II Data and assumptions

The actual lethality data for Coronavirus infection is estimated in a study at London Imperial College [1]. It is gender neutral and given in averages for age groups of ten years, which is left unchanged and treated as step function here. A constant attack rate by age across countries assumed, the weighted average lethality of SARS-CoV-2 for the current German population [3] results in 1.27% (0.68%-2.42%).

Mortality per age without Corona is acquired from the latest currently available population and deaths statistics in Germany [3][4] for 2018. 955 000 deaths per 83 016 000 people result in a yearly normal life mortality of 1.15%. For ages 100 and older data is extrapolated using totals from [5].

Generally, assumptions made try to find the most likely value or its upper limit, which is why, when in doubt, they were chosen such that the impact of Coronavirus would rather be overestimated. Not considered are the possibilities of significant virus mutations (and thus multiple infections), previously acquired immunities, differences in health care, correlations with other diseases or long-term effects to survivors of critical stages.

The population data for Germany is assumed to be without error, lethality errors are taken from their source. Consequent errors are calculated as maximum of the given 95% confidence interval to account for possible correlations.

	Life expectancy /years	Reduction through Coronavirus /years
0-year-old	80.689	0.001 (0.000-0.020)
10-year-old	81.024	0.005 (0.001-0.035)
20-year-old	81.128	0.019 (0.008-0.056)
30-year-old	81.313	0.043 (0.021-0.094)
40-year-old	81.593	0.066 (0.031-0.133)
50-year-old	82.152	0.188 (0.109-0.405)
60-year-old	83.346	0.441 (0.254-0.889)
70-year-old	85.503	0.642 (0.368-1.266)
80-year-old	88.688	0.639 (0.311-1.089)
90-year-old	93.784	0.256 (0.125-0.437)
Weighted avg.	**83.039**	**0.164** (0.090-0.329)

Table 1: Results for the life expectancy of the current German population and reduction if a person is infected at this age. Values are calculated for every age and shown in excerpts.

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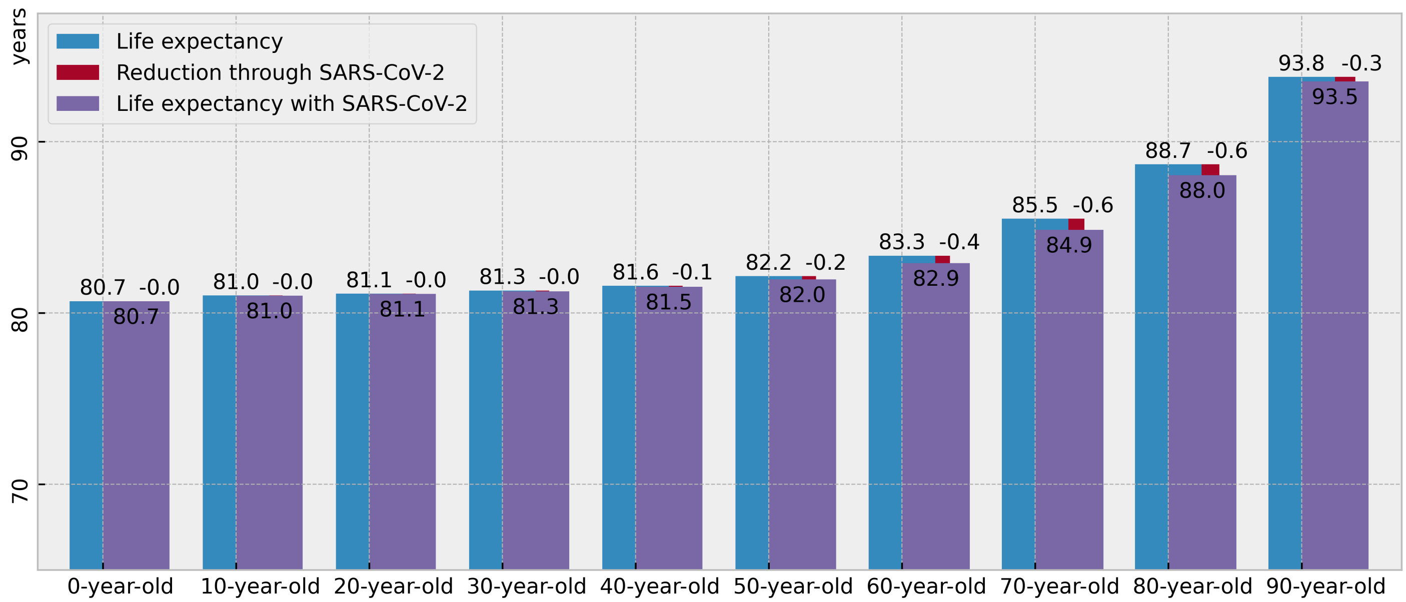

Figure 1: Illustration of the reduction in average life expectancy for the current German population. The life expectancy is cut below age 65 visually. See table 1 for more detailed values with respective errors.

III Detailed results

The life expectancy naturally increases for people who already reached a certain age as the as the possible death in all survived years did not occur for those. For newborns the value is the traditional definition of life expectancy. The difference can quantify the effect of a now found vaccine to Covid-19 ending the pandemic and thus the benefit of strict social isolation of every German until said vaccine is found.

As shown in Table 1, every German citizen would loose 0.164 (0.090-0.329) years in average for our total infection scenario. As expected, the value increases towards older ages due to the increasing lethality. It decreases again for ages 80 and older, when the decrease of remaining lifetime becomes more significant than any increase in lethality. This is why 70-year-olds suffer from the most reduction in life expectancy.

Those who die from COVID-19, and only those specifically, have 12.9 (9.6-18.5) average years of life lost (YLL) for themselves on death. This value is easily misinterpreted however, as it makes no statement about the impact on the population at all and is usually used comparatively.

IV Discussion

Although the average lethality was adjusted to German demography, the age group specific lethalities may still contain a small bias due to Chinese demography. In the same way, differences in health care systems as well as potential and occurred overloads may alter the values. When more precise data becomes available, *e. g.* for a shortage of breathing machines, the analysis can be easily redone.

Other known factors reducing the average life expectancy are physical inactivity with 0.95 years, social isolation with 0.51 years and smoking with 2.08 years for everyone in the German population [6]. In comparison to those, the 0.16 years for COVID-19 are significantly lower. However, the impact may differ from a political point of view, as COVID-19 would cause a rapid increase in total deaths. The fact, that deaths of other causes such as cancer would be reduced for the following decade, may get overlooked in the short term. Also, 9 out of 10 deaths due to COVID-19 could be prevented by protecting people of age 60 and older [2].

V Methods

Life expectancy is calculated for the present exact age h in one year steps as follows: Every year, the typical mortality $m(j)$ is applied and the chance $p_h(i)$ to reach and also die at a certain age i calculated.

$$p_h(i) = m(i) \cdot \prod_{j=h}^{i-1} (1 - m(j)) \tag{1}$$

A i-year-old dying to the annual mortality is assumed to reach an age of $i + 0.5$. The probability weighted average is taken for the life expectancy $le(h)$ at the given starting age.

$$le(h) = \sum_{i=h}^{\infty} (i + 0.5) \cdot p_h(i) \tag{2}$$

This is weighted with the current fraction $\frac{n(h)}{n_{\text{ges}}}$ of the population at given age to yield the demographically weighted average $\overline{le}$ of all individual life expectancies.

$$\overline{le} = \sum_{h=0}^{\infty} le(h) \cdot \frac{n(h)}{n_{\text{ges}}} \tag{3}$$

For the life expectancy with SARS-CoV-2 an additional lethality $l(h)$ is applied in the current year in the first equation such that

$$m_{\text{Corona}}(h) = 1 - (1 - m(h)) \cdot (1 - l(h)) \tag{4}$$

and the following steps are repeated.

VI References

[1] Verity R, Okell LC, Dorigatti I, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. *Lancet Infect Dis.*, 2020.

[2] Robert Koch-Institut. Steckbrief zur coronaviruskrankheit-2019 (covid-19). https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Steckbrief.html#doc13776792bodyText2. [Online; state 15.5.2020].

[3] Statistisches Bundesamt (Destatis). Gestorbene: Deutschland, jahre, geschlecht, altersjahre. https://www-genesis.destatis.de/genesis//online?operation=table&code=12613-0003&levelindex=0&levelid=1588715588289. [Online; accessed 17.5.2020].

[4] Statistisches Bundesamt (Destatis). Bevölkerung in deutschland, altersaufbau 2018. https://service.destatis.de/bevoelkerungspyramide/#!y=2018&v=2. [Online; accessed 17.5.2020].

[5] Baden-Württemberg Stiftung. *100! Was die Wissenschaft vom Altern weiß*. S. Hirzel Verlag, 2016.

[6] Nusselder WJ and Valverde JR. Impact of individual risk factors on german life expectancy. *Erasmus MC, Rotterdam*, 2018.