Research Note:

Estimating QALY losses associated with deaths in hospital (COVID-19)

Andrew Briggs

Version 3.0, 22nd April 2020

With the increasing death toll from the COVID-19 pandemic, a number of commentators have speculated as to the health burden of deaths associated with the virus. Anecdotal evidence suggests that death rates are higher with increasing age and that people with existing health conditions are particularly vulnerable.

With this in mind, this short note seeks to identify a simple to use and populate methodology to estimate likely QALY losses associated with premature death from COVID-19, based on standard life-table methods, conditioning on age and exploring the potential effect of comorbidities.

Standard life table approach to estimating life-expectancy

Life tables are produced nationally and show the numbers of people dying in one-year age bands across a population. We start by defining $q(x)$ as the probability of dying between ages x and $x+1$. From this we can calculate $l(x)$, for a reference population of 100,000, the number surviving to age x as:

$$l(x) = \prod_{a=1}^{x} \{1 - q(a)\}.$$

We now define $L(x)$ as the person-years lived between ages x and $x+1$:

$$L(x) = \frac{l(x) + l(x+1)}{2},$$

and the total number of person-years lived above age x as

$$T(x) = \sum_{u=x}^{\omega} L(u).$$

Now we calculate the life expectancy at age x as

$$LE(x) = \frac{T(x)}{l(x)}.$$

Adjusting the standard method

Three steps to adjusting the standard method are outlined below in order to introduce: 1) impact of comorbidity; 2) quality adjustment to estimate QALYs; and 3) discounting.

Comorbidities can increase a subject's risk of death. In epidemiology, the standardized mortality ratio (SMR) summarizes how a given comorbidity can increase the risk of dying. However, applying SMR directly to the probability of death within a period would risk the probability exceeding one, especially for older ages. We therefore estimate the underlying instantaneous rate, $r(x)$, that corresponds to the per period death probability, $q(x)$, and apply an SMR parameter to this underlying rate. This gives the equation for the reference population surviving to age x to give:

$$l(x) = \prod_{a=1}^{x} e^{-r(a)\cdot SMR}$$

where $r(x) = -ln\{1 - q(x)\}$.

Next we consider the use of quality adjustment. Standard population norm tables have been published for EQ-5D tariff values that can be used to adjust life-years to give quality adjusted life years (QALYs).[1] These tables give the population average quality of life tariff as a function of age x, $qol(x)$, Adding this as a weight to $L(x)$, along with an additional parameter to account for comorbidity impacts on quality of life, qCM, allows the calculation of a quality-adjusted $T(x)$ as

$$qT(x) = \sum_{u=x}^{\omega} L(u)\cdot qol(u)\cdot qCM.$$

The final step in providing an estimate of QALYs lost associated with a death at age x is to discount for differential timing. at rate r:

$$QALY(x) = \frac{\sum_{u=x}^{\omega} L(u)\cdot qol(u)\cdot qCM\cdot(1+r)^{-(u-x)}}{l(x)}.$$

Generating a weighted average QALY loss

The method above illustrates a possible approach for generating QALY losses associated with deaths from COVID-19 as a function of age and with the potential for differing assumptions about comorbidity. The results from the model are presented in the Table below for UK life table and quality adjustment data.

Table 1
Life expectancy (LE), quality adjusted life expectancy (QALE) and discounted QALYs (dQALY) as a function of age and SMR

		SMR=1 | qCM=100%			SMR=2 | qCM = 90%			SMR=3 | qCM=80%		
Age	dist	LE	QALE	dQALY	LE	QALE	dQALY	LE	QALE	dQALY
0-9	0%	76.45	66.41	27.65	69.56	55.16	24.23	65.34	46.38	21.07
10-19	0%	66.51	56.46	25.54	59.66	46.24	22.16	55.49	38.48	19.10
20-29	0%	56.69	47.07	23.29	49.99	37.87	19.89	45.94	31.13	16.96
30-39	1%	46.98	38.05	20.68	40.50	29.90	17.30	36.63	24.18	14.51
40-49	2%	37.49	29.38	17.51	31.35	22.33	14.17	27.78	17.64	11.61
50-59	5%	28.36	21.61	14.21	22.78	15.71	10.99	19.64	12.04	8.72
60-69	11%	19.86	14.76	10.75	15.11	10.12	7.82	12.59	7.46	5.94
70-79	27%	12.30	8.79	7.04	8.65	5.48	4.62	6.88	3.79	3.27
80-90	39%	6.42	4.52	3.95	4.05	2.48	2.25	3.05	1.56	1.44
90-100	16%	3.03	2.06	1.91	1.72	0.95	0.90	1.24	0.51	0.49
weighted mean		11.04	8.08	6.15	7.96	5.20	4.10	6.48	3.70	2.97

The final row of the table shows that mean quantities based on the weights shown in the second column of the Table. These percentages show the age distribution among patients who have died from COVID infection in UK.[2]

[1] For example see: https://www.springer.com/gp/book/9789400775954

[2] Data on age distribution of deaths from UK Office of National Statistics website (accessed 16 April 2020). https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsinvolvingcovid19englandandwales/deathsoccurringinmarch2020