
# Mortality and morbidity modeling considerations under COVID-19

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## Introduction

As the world continues to battle COVID-19 and emerging variants of the SARS-CoV-2 virus, the life and health insurance industry finds itself both reviewing lessons learned and preparing for what will happen next. While we now know much more about COVID-19 than we did 18 months ago, many important considerations – such as the disease's long-term health consequences and vaccination uptake across the globe – remain either unknown or unclear. (Re)insurers' ability to estimate COVID-19's current and future morbidity, mortality, and longevity impacts using actuarial techniques and scenario modeling is vital to continued progress.

Various short-term, medium-term, and long-term factors need to be taken into consideration and continuously adjusted when creating COVID-19 morbidity and mortality risk models.

## Short-term and medium-term factors

a. **Geographic location:** Experience patterns can significantly differ by country, population profiles, climate, and vaccine availability.

b. **Emerging experience and new variants**: COVID-19 morbidity and mortality rates have continued to mount globally. The pandemic is far from over, especially as variants continue to emerge and spread across the globe. The possibility of new variants needs to be considered if not expected.

c. **Public attitude and government actions:** Evolving public attitudes and government actions, such as lockdowns and travel restrictions, play crucial roles in influencing the course of the pandemic.

d. **Vaccine supply, uptake, effectiveness, and duration of immunity:** While vaccine supply in certain regions is sufficient, other localities are struggling to meet demand, with the deficit most significant in developing countries. At the same time, vaccine hesitancy and apathy, whether due to differing attitudes toward vaccines, misinformation, or other causes, are significantly influencing vaccine uptake across the globe. The delta variant has had a devastating impact globally, but data clearly demonstrate an ever-widening mortality gap between vaccinated and unvaccinated individuals. Emerging evidence also suggests that different vaccines have disparate levels of effectiveness against infection, severe illness, and death – and effectiveness also varies depending on the variant of SARS-CoV-2. There are also concerns over waning immunity over time, and the potential need for supplementary, or "booster," vaccine dosages. All of these factors need to be considered in modeling.

   See also: Duration of Natural and Vaccine-induced COVID-19 Immunity

e. **PASC (post-acute sequelae of SARS-CoV-2 infection):** Alternatively known as "long-haul COVID-19," this condition refers to the persistence of symptoms after the initial infection. A meta-analysis in the Nature Scientific Report identified more than 50 long-term effects of COVID-19, and more than 80% of the infected patients developed one or more long-term symptoms.[1] The National Institute for Health Research (NIHR) identified four subtypes of long COVID: post-viral fatigue, lasting organ damage (heart and lungs), fluctuating multi-system symptoms, and post-intensive-care symptoms.[2] Ongoing uncertainties remain over the prevalence, duration, severity, and ability to treat PASC, as well as its impact on mortality over time.

f. **Age and gender:** As identified early in the pandemic, age and gender are strong differentiating factors associated with COVID-19 mortality.[3]

   See also: COVID-19 Mortality Rates by Age and Gender: Why Is the Disease Killing More Men than Women?

g. **Demographical and physiological risk factors**: Published in 2020, a paper from RGA on risk amplification applied novel parallel multi-factorial modeling and concluded that the following factors, in addition to age and gender, increase the risk of COVID-19 mortality significantly more than the level observed for all-cause mortality: deprivation, identification as an ethnic minority, obesity, uncontrolled diabetes, reduced kidney function, stroke or dementia, and neurological conditions.[4]

   RGA's results were very consistent with a *Lancet Regional Health* paper published in May 2021 (six months later), which, in an analogous way, compared and contrasted COVID-19 versus non-COVID-19 mortality hazard ratios using comprehensive data from England's National Health Service (NHS) of 17 million patients via the OpenSAFELY platform.[5]

   The success of RGA's risk amplification results in accurately predicting COVID-19 mortality risk factors early on was echoed in cause-of-death statistics published later in the U.K., U.S., and Spain, which also associated these risk factors with excess deaths, further demonstrating the importance of understanding their impact.[6,7,8]

   See also: COVID-19 Mortality by Age, Gender, Ethnicity, Obesity, and Other Risk Factors: A Comparison Against All-Cause Mortality

h. **Accelerated deaths and survivorship bias:** The excess deaths directly attributed to COVID-19 are most likely not realized in a world without COVID-19. In other words, they are carried forward, or accelerated, from expected deaths in the future. This rate of acceleration largely depends on, firstly, the percentage of excess COVID-19 deaths, which depends on the duration and severity of the pandemic, and, secondly, the mortality risk differential in factors such as age, gender, and socio-economic status. All else being equal, accelerated deaths may bring forth lower than expected mortality rates, or "negative" excess deaths, in the future.

   Selection effect of the survivor cohort, or survivorship bias, could be induced by the disproportionate effect of COVID-19 on people with co-morbidities, resulting in a healthier survivor cohort than the pre-pandemic cohort. However, for older ages in England and Wales, Cairns et al. suggested the impact on the life expectancy of survivors will be small.[9]

   See also: Using the Gompertz model to estimate COVID-19 risk by age

i. **Underwriting and medical conditions:** When initial research began, certain comorbidities were associated with COVID-19 risk, leading to restrictions in underwriting for those conditions. While some of those restrictions have been lifted in certain markets, it is important to continue to monitor the data and adapt accordingly.

j. **Influenza:** During the pandemic, influenza has been curtailed by face covering, hand washing, and social distancing. If more of these, and other positive behavioral changes,

carry on to the future, flu seasons could potentially be less severe. On the other hand, the Medical Academy of Medical Sciences suggested that a surge of respiratory viruses could be more likely in the upcoming winter season in the U.K. because the population had limited exposure to these viruses during the previous winter.[2] The U.S. is already experiencing an unusual summer spike in respiratory syncytial virus (RSV) among children, especially in the southern states.[10]

k. **Economy, recession, and unemployment:** COVID-19 and associated lockdowns resulted in widespread shutdown of businesses, both temporary and permanent. A declining economy or recession could lead to greater unemployment, which is associated with decreased health and higher mortality. A National Bureau of Economic Research study on the U.S. population estimated that the size of the COVID-19-related unemployment shock is two to five times larger than the typical unemployment shock, resulting in a significant increase in mortality rates that translates to 0.84 and 1.22 million excess deaths over the next 15 and 20 years, respectively.[11] However, it is worth noting the uncertainty due to the improving unemployment rates over the past year.

   In the U.K., a Scientific Advisory Group for Emergencies (SAGE) paper, to which the Government Actuary's Department had contributed, estimated the recession resulting from COVID-19 in England could result in over 903,000 quality-adjusted life years (QALY) lost through increased morbidity in the medium term and 41,000 excess deaths in the medium and long term.[12]

   Conversely, it is possible that the negative impacts of recession could be counterbalanced by positive factors, such as a fall in road traffic accidents, reduced air pollution, improved exercise and diet, increased sleep time, and reduced risky behaviors. Some evidence from the U.S. and Canada suggests that increasing unemployment may lower the mortality rate of middle-aged individuals, with differences existing among different age groups. In addition, according to Miller et al., fewer seniors may die of cardiovascular and respiratory disease when the unemployment rate rises.[13]

l. **Delayed screening and medical intervention:** The pandemic affected screening, identification, and referral systems for cancer. These could lead to delays in treatment and worse outcomes. As a result of reduction of cancer services, Lai et al. estimated 7,165-17,910 excess deaths over one year in people with cancer in England.[14] Due to delayed screening, Alkatout et al. projected 315,000-350,000 additional deaths globally, including 6,400-7,000 deaths in the U.K., from lung, colorectal, breast, and esophageal cancer, up to five years after diagnosis.[15] Due to delay in diagnosis, Maringe et al. estimated an increase of 3,291-3,621 additional deaths within five years across the four major tumor types in England.[16] For every four weeks of delay in surgery, Hanna et al. estimated a 6-8% increase in risk of death; a surgical delay of 12 weeks for patients with breast cancer for a year would lead to 1,400 excess deaths in the U.K., 6,100 in the United States, 700 in Canada and 500 in Australia.[17]

   In addition to cancer, delays in diagnosis have been observed for type 2 diabetes, heart disease, and mental conditions.[2] Mafham et al. estimated a 40% reduction in hospital admissions of acute coronary syndrome in England, which is likely to result in increased out-of-hospital cardiac arrest and long-term complications of myocardial infarction.[18] Cardiovascular disease (CVD) management was impacted across the board, including prevention, referrals, diagnosis, treatment, and rehabilitation, according to research

from the Institute for Public Policy Research (IPPR) and Carnell Farrar. The study reported a 97% drop in health checks, a 19-45% drop in elective procedures, and a 36% drop in rehabilitation in the U.K. As a result of these missed health activities, the authors estimate that up to 470,000 patients will not have started on preventative cardiovascular or diabetic medications, and an additional 12,000 heart attacks or strokes might result in the future.[19]

m. **Wider health impacts:** There is growing evidence that COVID-19 has indirectly affected the general health and well-being of the population, including mental health, cognitive and physical deconditioning among older people, higher alcohol consumption, and substance use disorders. The pandemic has also consumed vast amounts of public funding and resulted in increased fatigue in the health and social care workforce.[2] Uncertainty remains about how much these factors, as well as lifestyle changes such as smoking and physical activity, will affect morbidity and mortality.

## Long-term factors

a. **Leveraging research and mRNA vaccines to improve life expectancy:** The pandemic catalyzed research and medical advances. RNA therapies that use mRNA technology are being harnessed to develop vaccines for personalized cancer therapy, infectious diseases (HIV, seasonal flu, malaria), autoimmune diseases, and rare disorders (cystic fibrosis, hemophilia).[20,21,22] COVID-19 demonstrated that mRNA vaccines can be an efficacious and safe technology, perhaps contributing to wider confidence and adoption.

   See also: mRNA Vaccines: Is the future now?

b. **Quality and access to healthcare and social care:** The quality of healthcare is a key driver of mortality improvement. A *Lancet* paper's systematic analysis of 137 low- and middle-income countries revealed that poor quality of healthcare was a major driver of excess mortality across medical conditions, where wider coverage and investments into high-quality systems could avert 8.6 million deaths.[23] In England, a high-income country with universal health coverage, Watkins et al. estimated that the public expenditure constraints between 2010 and 2014 were associated with 45,368 excess deaths when compared to pre-2010 trends.[24]

   COVID-19 has vividly exposed the vulnerability of healthcare systems and infrastructure around the world, but healthcare institutions could become more resilient as a result in areas such as primary care, eldercare, supply chain, digitalization, and public-private partnerships. On the flip side, lockdowns have inflicted deep damage to public finance and the wider economy that could have negative consequences on healthcare and social care funding.

c. **Pandemic risks, ecological changes, and "the big one"**: What is the risk of having one or more pandemics within the next few decades? While COVID-19 does not necessarily increase future pandemic risks, it does necessitate further investigation into the underlying drivers and the parameterization of (re)insurers' pandemic and capital models, as well as the actuarial assumptions.

The 50% growth in the world population in the last 30 years has produced significant climate and ecological changes, such as increasing human encroachment on wildlife habitats, deforestation, and intensive animal farming, which in turn expand the interface between human, livestock, and wildlife disease reservoirs. The World Health Organization has warned of "the big one," a pandemic with a substantially higher case fatality rate than COVID-19. Woo estimated there were as many as five near-miss pandemics in the past 20 years and suggested that ecological changes had shortened the return period of "the big one."[25]

d. **Preparedness for future pandemics:** A slim silver lining of the current pandemic is that lessons learned can help us better prepare for future outbreaks. There are learnings from many areas: public communication, test-and-trace initiatives, critical care capacity, global vaccination and manufacturing, real-time data analytics, and the importance of investment into pandemic preparation. Governments, public health experts, scientists, and universities will need to collaborate to build up better infectious disease surveillance and response capabilities and to reduce the mortality and economic burden of potential future pandemics.

## Modeling Considerations

Much uncertainty remains about the mortality and morbidity impacts of COVID-19 for both the near- and long-term. The longer the projection term, the greater the uncertainty. Yet actuarial toolkits can be used to model the impact while allowing for uncertainties, including comparing optimistic and pessimistic scenarios. Subjective judgment is required; therefore, utilizing cross-disciplinary expertise is recommended, including actuaries, epidemiologists, physicians, and other specialists.

The materiality of the impact of the many factors involved will differ by business lines and risk exposures. One modeling approach to incorporate these factors is to overlay their estimated net impact by granularity of credible risk factors, onto existing best estimate assumptions of short-term rates and long-term projections. Existing best estimate assumptions could come from either the pre-pandemic assumptions or the counterfactual scenario of a world without COVID-19. As an alternative to the above "add-on" approach, different weights could be applied to experience data during the pandemic if some of the experience is expected to continue into the future.

The preliminary steps could resemble the following:

i. Identify relevant short-term, medium-term, and long-term factors.
ii. Estimate frequency (likelihood of happening), severity (the net extent of positive or negative impact), and duration of the driving factors.
iii. Consider differences between insured and general population, or the socio-economic differences of the above factors
iv. Allow for uncertainties, for example by sensitivity and scenario testing, in projections. This is very important.

## Conclusions

Many experts now predict that COVID-19 is likely here to stay, much like other endemic diseases such as the flu.[26,27] Hopefully successful vaccination campaigns and other adaptations will make the disease much less deadly – as well as more predictable – moving forward. But until then, variables will continue to change, and COVID-19 models will continue to be imperfect, in need of constant monitoring and adjustments.

The insurance industry has an important role to play in providing financial security during these uncertain times. As the COVID-19 pandemic makes people more aware of the value of life and health insurance and the importance of protection, holistic and accurate modeling will be essential to providing the right coverage at the right price. The work we do and lessons we learn now will not only help us overcome the current crisis but may help prepare us for pandemics to come.

Committed to staying abreast of the latest research and new developments, **RGA's Global Data and Analytics associates are actively investigating the global impact of COVID-19.** Contact us **for more information.**

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