Establishing Methods for Annual Updates to Cohort Life Expectancies

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Establishing Methods for Annual Updates to Cohort Life Expectancies

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1. Introduction

Life expectancies estimate the average number of years of life a person who has attained a given age can expect to live in the future. This type of statistic has been a helpful demographic measure to compare differences between countries, and since the measure differs considerably by sex, age, race and geographic location, it is commonly given for specific subcategories of the population, rather than for the population in general.

National life expectancy estimates, such as those from the National Center for Health Statistics in the U.S., provide a reliable snapshot of population health and mortality and can help make comparisons over time consistent. In addition, for many years the annual changes in U.S. population mortality levels have been characterized and publicized conveniently through how they impact changes in period life expectancy for the population. These comparisons can be helpful, especially if changes in mortality rates are trending in smaller movements over time or can be used to compare how different eras have exhibited mortality levels through a life expectancy calculation. These life expectancy measures are most commonly determined in the form of period life expectancies (PLEs). The PLE assumes that the age-specific death rates for the year in question will apply throughout the lifetime of individuals born in that year.

When large annual changes in mortality occur, however, the result is to find amplified changes in the PLE. The new PLE statistic calculated after a large mortality change presumes that the population would be exposed to the new annual mortality rates every year forever, and that no future health or technology advancements would be realized to potentially mitigate the new mortality levels. This has been the case during the COVID-19 era, when large changes in annual mortality rates have occurred and the resulting period life expectancy changes have been much larger than in any recent times.

With that in mind, this paper considers methods that can be used consistently to look at annual changes in mortality and life expectancy measures beyond the PLE. Cohort life expectancies (CLEs) are another type of measure that calculates the average number of additional years a person would live considering assumed future changes in mortality for their cohort over the remainder of their life. CLE calculations allow some flexibility to presume that future mortality levels may change, which is consistent with actually observed mortality over time. A wide variety of methods can be considered to build various CLE measures, and this paper will investigate some of them in light of recent trends seen from the COVID pandemic era.

2. Recent Examples

As a starting example it can be helpful to investigate changes in PLE measures prior to the pandemic. In the late 2010s mortality shifts in the U.S. population were not large, and annual mortality improvement was hovering generally between small disimprovements and 1.0% positive improvement. For calendar year 2018, the National Center for Health Statistics (NCHS), part of the U.S. Centers for Disease Control and Prevention (CDC), published their annual United States Life Tables. For convenience, initial examples will look at the full population as a whole, without common subdivisions often reported by sex, race and geographic location. The 2018 and 2019 data are summarized in Table 1.

Table 1
SUMMARY OF U.S. LIFE TABLES FOR 2018 AND 2019

Age	2018 Mortality Rate (Deaths per 1,000)	2019 Mortality Rate (Deaths per 1,000)	Mortality Improvement /Change
0	5.65	5.57	1.3%
25	1.07	1.06	1.6%
45	2.65	2.68	−0.9%
65	12.69	12.62	0.6%
85	81.64	80.53	1.4%
99	317.52	308.77	2.8%
Period life expectancy at birth (PLE) (years)	78.7	78.8	0.1

With the COVID pandemic emerging in 2020, population mortality around the world was severely impacted. For the first time in U.S. history the country exceeded 3 million deaths in a calendar year, recording well over 3.3 million during 2020. Life Expectancy Estimates for 2020 have been published by the CDC, with mortality rates generally published currently at five-year intervals rather than published in a full life table for 2020. Estimates for 2020 population mortality rates can be proxied by the data for mortality in 2020 used by the U.S. Social Security Administration in their financial projections. When looking strictly at PLE calculations, the fact that current year mortality is used at all ages creates a situation in which one sees very large shifts in the PLE. From 2019 to 2020, when using strict PLE calculations, the PLE at birth decreased by 1.8 years from 78.8 years to 77.0 years.

Table 2
SUMMARY OF U.S. LIFE TABLES FOR 2019 AND 2020

Age	2019 Mortality Rate (Deaths per 1,000)	2020 Mortality Rate (Deaths per 1,000)	Mortality Improvement /Change
0	5.57	4.88	12.6%
25	1.06	1.25	−18.2%
45	2.68	3.05	−14.0%
65	12.62	14.87	−17.8v
85	80.53	97.48	−21.0%
99	308.77	355.69	−15.2%
Period life expectancy at birth (PLE) (years)	78.8	77.0	−1.8

The large drop in PLE at birth was the largest that had been seen in the U.S. in more than 100 years. PLE at birth dropped from 50.9 years to 39.1 years from 1917 to 1918 because of the impact of the influenza pandemic caused by an H1N1 virus. PLE at birth rose 15.6 years from 1918 to 1919 to a new higher level of 54.7 years.

3. Considering Options for Calculating CLEs at Birth

Although mortality was definitely severe in 2020, the dramatic decrease in PLE at birth poses the question of how much this statistic should be used for the sole indicator of current and future mortality trends expected in the population. Cohort life expectancy (CLE) at birth and other ages is helpful to consider, because it has the potential to mitigate the influence of strong but potentially temporary mortality events and build in any mortality improvement (or disimprovement) trends seen in recent times across the population.

The Society of Actuaries Research Institute's (SOA) work on mortality improvement models in recent years can be a guide as to how current mortality along with current and future improvement trends can build a steadier stream of CLEs at birth and other ages. A generic function of building a CLE at birth might be viewed through the following set of questions:

- How should researchers using the CLE consider the starting point for the base mortality rates? The base mortality assumption might be the actually observed mortality for the current year being evaluated. Alternatively, in the case of an extreme mortality event that is not expected to recur in the future, one may want the current mortality to leverage more off of the next most recent observation. Extreme mortality may occur from several sources, such as a health pandemic or the influence of a war that inflates mortality rates. We can describe this starting base mortality through potential weighting of the mortality in the most recent and the next most recent years, and whether the current year needs base mortality adjusted from influencing current events.

  Potential weighting of the mortality is CLE base mortality in year *t* (*a*% weight from year *t*–1; *b*% weight from year *t*, adjusted or nonadjusted for current year extreme events).

  Calculations for PLE base mortality are a subset of the range of possibilities for CLE base mortality with PLE base mortality in year *t* = CLE base mortality in year *t* (*a* = 0%; *b* = 100%, nonadjusted).

- How should past mortality improvement leading up to the current year be used for a short-term future year mortality improvement rate and transition to a long-term improvement rate? Current SOA mortality improvement models transition from the current mortality rate using a cubic-splining process to target a long-term improvement rate at a designated point in time in the future (typically in 10–20 years) with additional possible modifications that may also be done at very high attained ages. The long-term rate chosen may be best estimated from observations from recent decades. For this investigation, the assumption will be that the long-term mortality improvement target will be some weighted average of the past 20 years of mortality improvement.

  The CLE long-term mortality improvement target is

  $$\sum_{n=t-19}^{t}((MI\ Rate_x)_n\ (MI\ Weight)_n; adjusted\ or\ nonadjusted\ for\ extreme\ events)$$

  where the mortality improvement (MI) weights over time add up to 100%

  Calculations for PLE long-term mortality Improvements are again a subset of the range of possibilities for these CLE targets with $(MI\ Rate)_t$= 0 for all values of *t*.

With these definitions, it is possible to look back over recent years to generate the various CLE long-term mortality improvement targets for each age, next insert them into the SOA Mortality Improvement Model to generate what the future cohort mortality improvement rates would be, and then apply them to the CLE base mortality in year *t* to come up with an estimate of statistics such as the CLE at birth for recent years.

4. Longitudinal PLEs and CLEs at Birth in Recent Years

By using a consistent approach for determining the assumptions for calculating a CLE at birth, a longitudinal series can be established to see how dramatic changes in both PLE and CLE play out. Table 3 highlights these trends over recent years, including a look at the potential estimates of CLE at birth in 2020.

Table 3

SUMMARY OF U.S. LIFE TABLES, PLE AT BIRTH AND CLE AT BIRTH FOR 2016–2020

Year	2016	2017	2018	2019	2020 (No COVID Adjustment, without Mortality Improvement)	2020 (COVID Adjusted, with Mortality Improvement)
PLE mortality rates						
Age 0	5.86	5.78	5.65	5.57	4.88	
Age 25	1.11	1.12	1.07	1.06	1.25	
Age 45	2.62	2.65	2.65	2.68	3.05	
Age 65	12.71	12.71	12.69	12.62	14.87	
Age 85	81.19	81.95	81.64	80.53	97.48	
Age 99	304.08	316.46	317.52	308.77	355.69	
Period life expectancy at birth (PLE) (years)	78.7	78.6	78.7	78.8	77.0	
Change from previous year		−0.1	0.1	0.1	−1.8	
Mortality rates for CLE						
Age 0	5.86	5.78	5.65	5.57		4.87
Age 25	1.27	1.41	1.40	1.38		1.59
Age 45	2.14	2.31	2.37	2.40		2.48
Age 65	5.31	5.56	5.55	5.51		5.74
Age 85	37.77	37.85	36.51	36.01		38.22
Age 99	249.21	250.21	243.23	236.53		240.07
Cohort life expectancy at birth (CLE) (years)	84.5	84.1	84.2	84.3		83.6
Change from previous year		−0.4	0.1	0.1		−0.7

COVID-adjusted mortality rates are created by reversing the impact of COVID during 2020 but retaining additional excess non-COVID mortality.

5. Observations and Opportunities for Further Research

Creating more standard approaches for using CLE allows for a few additional opportunities, including the following:

- CLE calculations allow for a broader conversation in the way mortality improvement impacts future life expectancies. Whether improvement is positive or negative, these types of calculations should bring it into the overall conversation and analysis. PLE calculations put blinders on the concept of mortality improvement, or alternatively can be seen to presume that “mortality improvement is perpetually 0% annually.”
- CLE calculations allow changes in annual statistics to be able to be decomposed into two distinct components:
    - How much of the change is due to current year mortality levels and

- How much of the change is due to the average change in mortality improvement that has been seen in recent years.

- Although this paper doesn't show the results for CLE calculations at a typical retirement age, doing the similar calculations at attained age 65 would provide a more realistic look forward to what retirees might actually expect in terms of future lifetime. In addition, failing to recognize both extreme (potentially nonrecurring) mortality events and mortality improvement may cause retirees to make unnecessary drastic changes to their retirement planning.
- Using a CLE method allows potential use past experience to provide insights for the best way to make future estimates. Further study could be done for CLEs at age 65 over the past 30 to 40 years, and noting what actually observed average lifetimes have emerged compared to what CLE estimates would have been under various assumptions. It may turn out that a CLE at age 65 is best estimated by using something different from a 20-year average past mortality improvement assumption in the SOA model. Perhaps 15-year or 25-year averages are better indicators compared to what has been actually historically observed. This can help better refine the methods for determining CLEs.

Additional research and development of opportunities can be pursued, with a main opportunity being to mitigate the large fluctuations often seen in period life expectancies.

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