General description of mortality projection methods
Sam Gutterman, December 12, 2014

Three major types of mortality projection methods have been referred to as explanation, extrapolation and expectation[i]. Any of these methods can be applied at the aggregate or sub-population levels (the latter could grouped by risk characteristic, such as age, gender, year of birth, racial/ethnic group or smoking status). These methods are also not necessarily mutually exclusive, as many projections that have been performed have included elements of more than one approach.

The following is not meant to be an exhaustive discussion of alternative approaches or formulae, nor a description of any specific method. Rather, it is intended to provide an overview of the arguments that have been advanced and does not take a position regarding these arguments. In some cases, the arguments indicated relate to the general method and in others they relate to the specific application of the method by OCACT. In addition, all methods are imperfect guides to the future and share certain advantages and disadvantages, e.g., unanticipated black swan conditions or those that have not historically been reflected in the experience base period are difficult to incorporate and the historical period over which experience is considered is always judgmental.

Explanation

Explanation methods explicitly reflect parameters that help explain (either through correlation or causation) or drive the patterns and expected changes in mortality experience. They often take the form of mortality decomposition (by cause of death). Informal approaches implicitly reflect expected external conditions, while formal approaches reflect these in an explicit manner.

Arguments in favor:

1. Theoretically, since is desirable to reflect in any projection the drivers or causes of death, this method should be superior
2. Focuses on understanding and reflecting the consequences of what has happened and are expected to happen in the future
3. Easier to apply what-if or alternative scenarios and sensitivities that can be understood.

Arguments against:

1. Overly complex (SSA uses 70 parameters)
2. Selection of factors are necessarily overly judgmental, which are speculative, at best
3. Requires projections of causes of death that are currently unrecognized or underappreciated, e.g., projecting the "other" category
4. Has usually proven to be unduly pessimistic (when projecting improvements; may be optimistic for causes of death projected to experience a negative improvement)
5. Improvement rates over the long-term tend to be dominated by causes of death that are projected to increase (or decrease less than the others), because the frequency of deaths from those causes with greater projected improvement will be less important in the later part of the projection period, thus automatically leading to rates of improvement that may be too low in the future
6. Rarely reflects correlation among causes (e.g., the impact of a continuing rate of decline in deaths due to cardiovascular disease on rates of cancer or other causes), i.e., causes of death are not independent, although the approach usually assumes they are

7. Although it may be possible to decompose historical results, future causes or contributors to mortality over a 75 year period is beyond the ability of modelers
8. Results in discontinuities in mortality by adjoining age (a result of use in improvement factors of age groups, rather than individual ages)
9. Sources of cause of death data are often inaccurate or available for a limited period of time recorded in a consistent manner, especially at older ages where multiple causes of death are common and where there have been changes in recording cause of death (e.g., due to changed realization of causes, in part earlier resulted in an increase in reported dementia deaths)
10. May require ad hoc adjustments if, because of cause of death assumptions, a prior overall relativities (e.g., female mortality rates less than males) are not maintained
11. Because of a smaller amount of data, experience for certain cause of death categories may not be sufficiently large, leading to unstable estimators
12. Insufficient documentation of the basis for selecting cause of death improvement factors (SSA specific) leading to a lack of transparency.

There are several de-compositions that are possible, e.g., multiple formulations of cause of death categories, levels (such as those with different smoking status) or income level.

Extrapolation

Historically, there have been many formulas used to project mortality rates. Initially they included well-known parametric models such as those referred to as Gompertz and Makeham's. In the 1990s, a new approach referred to as the Lee-Carter model[ii], a relatively simple two-factor (attained age and period, which assumes relative mortality rates by age remain constant in the future) model of statistical extrapolation, which many mortality modelers have been using ever since, often with some variation, making it a family of models.

Arguments in favor:

1. The primary method used around the world (except for SSA and in specialized studies, e.g., what-if a change in a specific cause of death)
2. Fewer selections to make.

Arguments against:

1. Ignores known changes in conditions affecting mortality, e.g., smoking, and incorporates in its historical base conditions that are not likely to re-occur (e.g., HIV/AIDS effects on young adult males)
2. If carried out mindlessly for too long a period, unrealistic results may be projected (e.g., below expected rates for accidents)
3. At best could be characterized as naïve extrapolations
4. Judgmental with respect to the number of years of experience included used to base the extrapolation
5. Assumes, at least in the original Lee-Carter approach, that mortality relationships by age remain constant over the projection horizon, which may not be realistic
6. Possible model miss-specification if key variables are not incorporated (e.g., effect of smoking).

Expectation

Most expectation approaches incorporate expert opinion regarding future mortality level or rates of mortality improvement. These opinions can be derived from those who are experienced in one of several fields, such as medical practitioners or mortality analysts. They are often expressed in terms of values over a given period of time, such as, percent reduction in rate of cardiovascular deaths over the next twenty years.

Arguments in favor:

1. Avoids naïve projections
2. Reflects best understanding of the factors that might affect future rates of mortality.

Arguments against:

1. Has in some cases tended to be overly pessimistic, in part because most opinions tend to be conservative, that is, not recognizing extreme developments.

[i] Booth, H., L. Tickle (2008). "Mortality modelling and forecasting: a review of methods". *Annals of Actuarial Science*. V3, I/II, 3-43.
[ii] Lee, R.D., L.R. Carter (1992). "Modeling and forecasting U.S. mortality." *Journal of the American Statistical Association.* 87(419), 659-671.