# Forecasting US Mortality

**Neal Marquez**

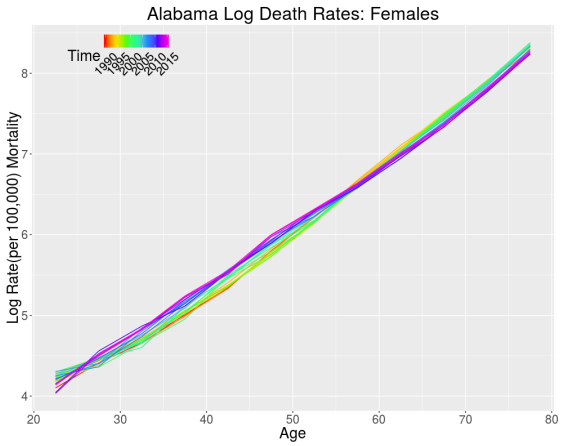
## Modeling Mortality

Modeling human mortality has had a long history of attempts and revisions since Gompertz first made his claim of human mortality patterns in the 1880s. The ability to accurately model and describe rates of mortality can have numerous effects on how social institutions and policies can be structured in order to meet the needs of its populations. For example knowing the age pattern of mortality allows a society to build the medical infrastructure to cope with the needs of different aged individuals. Knowing the root causes of mortality allow for the change of policy in order to reduce specific drivers of mortality.

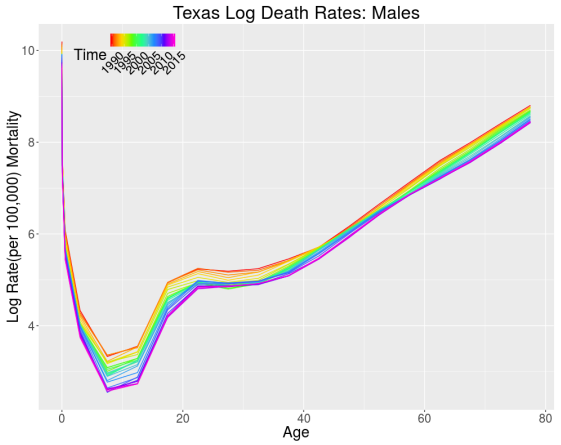
Another aspect of mortality that is often of concern is the future rates and how they differ from the past. Over the past century there has been dramatic declines in mortality across all locations and ages. While that progress has stagnated to some degree we still see dramatic decreases in mortality among developing countries where medical infrastructure is expanding and improving. As this happens we would expect there to be a direct effects on the population, production and needs of a society.

## History of Descriptive Models

Descriptive models of mortality have an inherent age structure to them that allow for a simple descriptive explanation of how death effects individuals across their life-span. Gompertz first claim about human mortality was that there is a linear increase in log rate mortality as one aged. Below is an example of this phenomenon where we graph the log rate mortality of Women in Alabama between the ages of 22 and 77.




While this model holds well for older ages, those who are part of the senescence group, younger individuals experience quiet different mortality patterns as they age. From birth the rate of mortality decreases until the senescence period is started at which time the mortality rates will then again increase. Below is the log rate mortality for males in Texas which shows this pattern that is nearly a human universal.




In order to capture this in 1983 Siler proposed a model to capture this switch in mortality patterns by decompsing rate of mortality into three terms, an infant mortality term, a constant risk term and a senescence term.

$$m_x = \alpha exp(\beta x) + c + \delta exp(\eta x)$$

This model of mortality captures the change across ages well but still only applies to a single location of interest for a single snapshot in time. Others have proposed more complex models, see Heligman-Pollard 1980, however as more terms have

been added to try and capture subtle nuances of mortality the generalizable usefulness of the model tends to suffer.

## Forecasting and Lee Carter

These models all offer a descriptive frame work for mortality over age however the do not offer a good solution for mortality over time or across regions. In 2000 Lee & Carter developed a model that is till this day widely used for forecasting mortality at the all_cause and cause specific level. Abandoning the traditional framework of looking at age patterns the model argues that better forecasts can be made by assuming that ages are largely independent in their level and only similar in their rate of change. In doing so the correlation between ages is lost and as the forecasted model continues outward it will propagate differences between age groups. The model is as follows

$$m_{at} \sim \mathcal{N}(\mu_{at}, \sigma^2)$$
$$\mu_{at} = \beta a \gamma t$$
$$\gamma_t = \gamma_{t-1} + \theta + \epsilon_t$$
$$\epsilon_t \sim \mathcal{N}(0, \sigma^2_{rw})$$

While this model has preformed well when tested on US mortality data from 1970 to 2005 within the US it has performed lackluster in other environments. Because of the lack of age structure th model produces nonsensical results where adjacent age groups have differing and sometimes opposite rates of change log rate mortality. in 2006 Girosi and King wrote a response to the model showing where the model works well and the many times that it doesnt and criticizing the approach for not pooling information across age and geography.

## Modified GeoTemporal Siler

In order to fit all the dimensions of concern while still maintaining a coherent age structure this project attempts to use a modification of the Siler model which accounts for deviations away from the expected value due to relatedness across multiple dimensions while also including temporal change.