**METHODOLOGY**

* 1. **The Lee-Carter Model (1992)**

Lee-Carter Model is a numerical algorithm which is used to forecast mortality and life expectancy. By using age-specific death rates, Lee-Carter Model (1992) estimates an index of the level of mortality called. I calculated this index for the lives of under-5 year’s old children. Once the index of the level of mortality was forecasted, it was possible to predict the death rates of the under-5-year-old children up to the year 2030.

* + 1. **The Model**

The model’s basic premise is that there is a linear relationship among the logarithm of age-specific death rates *mx,t* and two explanatory factors: the initial age interval *x,* and time *t.* The equation that describes this is as follows:

ln(*mx,t*) = *ax + bxkt + ex,t*(i)

Where;

*mx,t*: is the age-specific death rate for the *x* interval and the year *t.*

*kt*: Is the mortality index in the year t and is usually linear hence modeled as a random walk.

*ax*: Is the average age-specific mortality.

*bx*: Is a deviation in mortality due to changes in the *kt* index.

*ex,t*: Is the random error term associated with age group x and time t

*ex,t ~ N(0,σ2)*

* + 1. **Assumptions of the model**

The model assumes that bx is invariant over time (does not change) over the years.

* 1. **Estimation of Parameters**
     1. **Estimation Using SVD**

Singular Value Decomposition is a method used in the approximation of a matrix as a product of two vectors. I estimated the value of *a* through averaging the logarithm rates over time.

I then went ahead to apply Singular Value Decomposition to estimate the values of *bx* and *kt.*The SVD produces a product of three matrices

Where;

U: Matrix accounting for the element of age

S: Matrix accounting for the singular values

V: Matrix accounting for the time element

The value of *kt* is derived from time element matrix and the value of *bx*is derived from the matrix accounting for the age-component. After this I adjusted the value of *k* in order to predict the total number of deaths in the subsequent years correctly. In the adjustment I used the iterative method whereby

* 1. **Forecasting**

To produce mortality forecasts, I sustained the Lee and Carter assumption that the value of *bx* and *ax* remains constant over time. I then used the forecasts of *kt* by the use of the random walk with drift ARIMA model as follows:

*Kt = kt-1 + θ* + *et*

Where;

*θ* is known as the drift parameter whose MLE is obtained as follows

*kt* is the last calculated value of *kt,*

*k1*is first calculated value of *kt,*

­*T-1* is the difference in time.

* 1. **The Cairns-Blake-Dowd Model (CBD)**

In this new era of stochastic mortality modeling, CBD model serves as a viable contestant among different stochastic models. I therefore considered it as a second model of forecasting alongside Lee-Carter Model with the aim of determining the most reliable to use in our final projection. The model was introduced by Cairns et al. (2006).

* + 1. **The Model**

The formulation of the model I decided to use was the original model that Cairns et al (2006) provided. The equation of the model is as follows:

Where:

–This is the intercept of the model. It represents the level of mortality at time t.

– Represents the slope of the model and it affects every age differently.

– Mean age of the considered interval of ages.

x – Particular ages considered.

– The error term that encloses the historical trend that the model does not express. Assumed identically and independently distributed.

– Probability of death for an individual aged x at time t.

* + 1. **Assumptions of the Model**
  1. **Estimation of Parameters** 
     1. **Estimation Using MLE**

Maximum Likelihood Estimation (MLE) is the method used in the estimation of CBD parameters. The method is based on the Poisson error structure according to Brouhns et al. (2002). I treat parameters and as a bivariate random walk with drift process for the purpose of future mortality projection. This can be defined as.