Understanding and Managing Healthy Life Expectancy

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Motivation

- Motivated by keynote speaker at 2016 Actuarial Research Conference
  - ✓ Life expectancy will not increase indefinitely into the future
  - ✓ Similar to a machine, the human body is expected to break down eventually despite medical advances, anti-aging drugs, etc.
- Since we cannot hope to live indefinitely, we want to maximize the quality of life over the limited time we have – hence the concept of Healthy Life Expectancy or HLE for short

Definition of HLE

- Defined as the expected future lifetime that one stays healthy
- Termination from a healthy state occurs by death or disability
- Disability uses a long term care definition which is inability to perform some of the activities of daily living
- The only recovery from disability is death
- In contrast, Unhealthy Life Expectancy (ULE) is the expected future lifetime that one stays unhealthy
- HLE + ULE = Life Expectancy (LE)

Literature review on HLE

- Concept of healthy living is well established in the literature
  - ✓ Articles generally determine HLE on a macro level using population statistics versus on an individual level
  - ✓ None of the HLE models use actuarial probabilities of mortality and morbidity or clearly spell out their calculations

- The Goldenson Center research on HLE is the first time:
  - ✓ such a calculation has been done on an individual basis
  - ✓ uses established actuarial assumptions of mortality and morbidity
  - ✓ based on a multiple decrement modeling approach

Input Assumptions

- Healthy attained age mortality rates
  - ✓ Uses first year select SOA mortality rates
- Incidence rates of disability
  - ✓ Based on SOA long term care incidence rates
- Attained age mortality rates for disabled lives
  - ✓ Based on SOA RP 2014 mortality rates for disabled lives
- Personal information – gender, age, smoker status, exercise and dietary habits, body mass index, income, education level, marital status, sleep habits

Model Calculations and Output

- Adjustment factors to input actuarial assumptions based on personal information
- Annual total mortality rates of combined healthy and disabled lives
- Life expectancy calculations:
  - ✓ Healthy life expectancy
  - ✓ Unhealthy life expectancy
  - ✓ HLE relative index
- Unhealthy life expectancy calculation adjusted for cognitive disability

Glimpse of some of the actuarial formulas

- $q_x^{(h)}$= *P*(Healthy life (x) dies in the coming year)
- i_x = *P*(Healthy life (x) gets disabled at the start of the year)
- $q_x^{(d)}$= *P*(Disabled life (x) dies in the coming year)
- Then $q_{x+k}^{(T)}$ = *P*(Healthy life (x) dies between x+k and x+k+1) = ${}_kp_x^{(h)}(1 - i_{x+k})\, q_{x+k}^{(h)} + \sum_{t=0}^{k} {}_tp_x^{(h)}\, i_{x+t}\, [{}_{k-t|}q_{x+t}^{(d)}]$

Validation of formulas

- Separate formulas developed for HLE, ULE and LE and one test was to ensure LE = HLE + ULE
- Independent validation using Monte Carlo simulations with actuarial input assumptions to reproduce analytically developed calculations
- Monte Carlo simulations had the added benefit of providing a distribution of realized HLE's
  - ✓ Quantiles of HLE distribution used to develop adjustment factors for input actuarial assumptions based on personal data

Adjustment factors in HLE calculations

- Calculations naturally adjusted for age, gender and smoking class since input actuarial assumptions varied by these factors.
- A literature review was done to study the impact of other personal factors like diet, exercise, income, education, etc. on mortality and morbidity
  - ✓ Adjustment factors were developed to match a specific quantile in the HLE distribution
  - ✓ A multiplicative approach was used to combine the personal factors
  - ✓ Process involved both judgment and actuarial rigor

Some illustrative results: Unhealthy Candidate

- Male 60, non-smoker, 5 ft 10in, 230 lbs
- Rarely exercises; < 5 hours sleep; 3-7 drinks per week
- Graduate and annual earnings > $100,000
- Diet and state of health fair

Output

HLE = 22.8 years

ULE = 3.5 years

Cognitive adjusted ULE = 8.1 years

Some illustrative results: Healthy Candidate

- Male 60, non-smoker, 5 ft 10in, 180 lbs
- Exercises 3 – 4 days per week; > 8hours sleep; 2 to 3 drinks per week
- Graduate and annual earnings > $100,000
- Diet and state of health very good

Output

HLE = 34.8 years

ULE = 2.5 years

Cognitive adjusted ULE = 4.7 years

Comments on examples

- Incorporating a healthier lifestyle:
  - ✓ Increases healthy living by 12 years
  - ✓ Causes an increase in ULE by only two years for cognitive adjusted disabled mortality rates
- Incorporating an unhealthy lifestyle:
  - ✓ Causes an increase in ULE by 5 years for cognitive adjusted disabled mortality rates

Application to individual financial planning

- Annual retirement spending should not be level across expected lifetime of individual
- During HLE period, retirement spending should be maximized subject to a given level of annual basic expenses
- During ULE period, basic expenses are expected to increase but discretionary expenses will be significantly reduced
- Incorporating HLE and ULE in a financial planning model will significantly change optimal spending patterns

Financial planning illustrative example

- Assume initial assets of \$1.5M, i = 6%, HLE = 22 years and ULE = 8 years
- Assume p.v. of basic expenses = 20% of initial assets
- Assume basic expenses are double over ULE period and there are no discretionary expenses

Results of financial planning example

- Financial planning not based on HLE:
  - ✓ Annual spending over LE of 30 years approximately $103,000
- Financial planning model based on HLE:
  - ✓ Annual spending over HLE approximately $112,000
  - ✓ Annual spending over ULE approximately $41,000
  - Additional annual discretionary spending is $9,000 or approximately $750 of additional monthly spending

Application to long term care design and pricing

- An HLE deferred life annuity for a limited duration of ULE years could be used as a substitute or to complement a long term care policy purchase
- LTC policies could be designed as a deferred limited duration coverage product based on HLE and ULE estimates at underwriting
- The cognitive-adjusted ULE could be used to estimate the additional costs incurred arising from a cognitive disability in LTC

Application to health care cost estimation

- The HLE model can be enhanced to incorporate:
  - a more general definition of healthy and unhealthy mortality rates
  - more detailed lifestyle and dietary details
  - serve as a patient screening tool for medical providers
- The enhanced HLE relative index could be used to develop risk classes for patients and be incorporated into a health care cost predictive model

Application to underwriting

- The creation of a model which can explicitly measure HLE and demonstrate the impact of lifestyle practices on HLE can add more rigor to current simplified underwriting practices:
  - ✓ Model results can be obtained in real time
  - ✓ HLE relative index can be used to differentiate between high and low risk individuals

Application as a wellness tool

- HLE is not a manifest destiny for an individual
  - ✓ Lifestyle changes (exercise, diet, sleep, etc.) can have a significant impact on HLE (and ULE)
  - ✓ Easy to understand and communicate that increasing HLE increases an individual's quality of life
  - ✓ Understanding HLE and how to maximize it can influence an individual's retirement lifestyle

Concluding remarks and next steps

- Quality of life is directly related to one's state of health
- The research by the Goldenson Center on HLE enables "quality of life" to be quantified explicitly
- Many open research questions are available on how to incorporate more rigor on explicitly measuring lifestyle changes on HLE
- This research has applications in financial planning, product design, underwriting, healthcare assessment and as a wellness tool

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