NOVEL APPROACHES TO UNIFY MULTI-STATE TRANSITION MODELLING METHODS AND DEVELOP A SYNTHETIC ENGLISH POPULATION TO SUPPORT HEALTH ECONOMIC EVALUATION STUDIES

Kettle J[1], Treharne C[1], Chan M S[1].

1 Health Analytics, Lane Clark & Peacock LLP. London, UK

Aims

- General population health transition data are frequently unavailable in a suitable format to support evaluation studies, including cost-effectiveness, health policy and intervention modelling.
- We aimed to:
  - Develop a representative synthetic English population capturing health status at small area level.
  - Apply three key multi-state transition modelling methods for estimating life expectancies (LEs) and healthy life expectancies (HLEs): the Sullivan life table method, continuous-time Markov models and discrete-time Markov models.

Introduction

- Health expectancy is a broad term for estimating the proportion of years lived in healthy and unhealthy states. The definition of health used varies depending on available data and the health states considered[1].
- We consider HLE as defined by the Office for National Statistics (ONS), using self-reported good health from census and population health survey data in the UK[2].
- Both LEs and HLEs can provide an indication of population health levels, and across the UK, disparities are observed by geography and by deprivation[3].
- Of the twelve priority missions announced by the UK government in their Levelling Up White paper in 2022, only one related to health: to increase national HLE by 5 years by 2035 and to narrow the HLE gap between the least and most advantaged areas in the UK[4].
- Given the importance of HLEs, we explore and compare 3 different methods for their estimation.

Estimation Methods

Method 1: Sullivan lifetable method

- This was the first method adopted to estimate health expectancies and requires cross-sectional population survey data to generate age-specific distributions of the population by health state at the time of the survey[1,5].
- These, along with age-specific mortality data from period life tables, are used to calculate health expectancy[1,5].
- As the required data is generally already collected in national surveys, this is the most widely used method for calculating health expectancy[5].
- We use ONS HLE estimates in the UK as a basis for comparison with the other two methods.

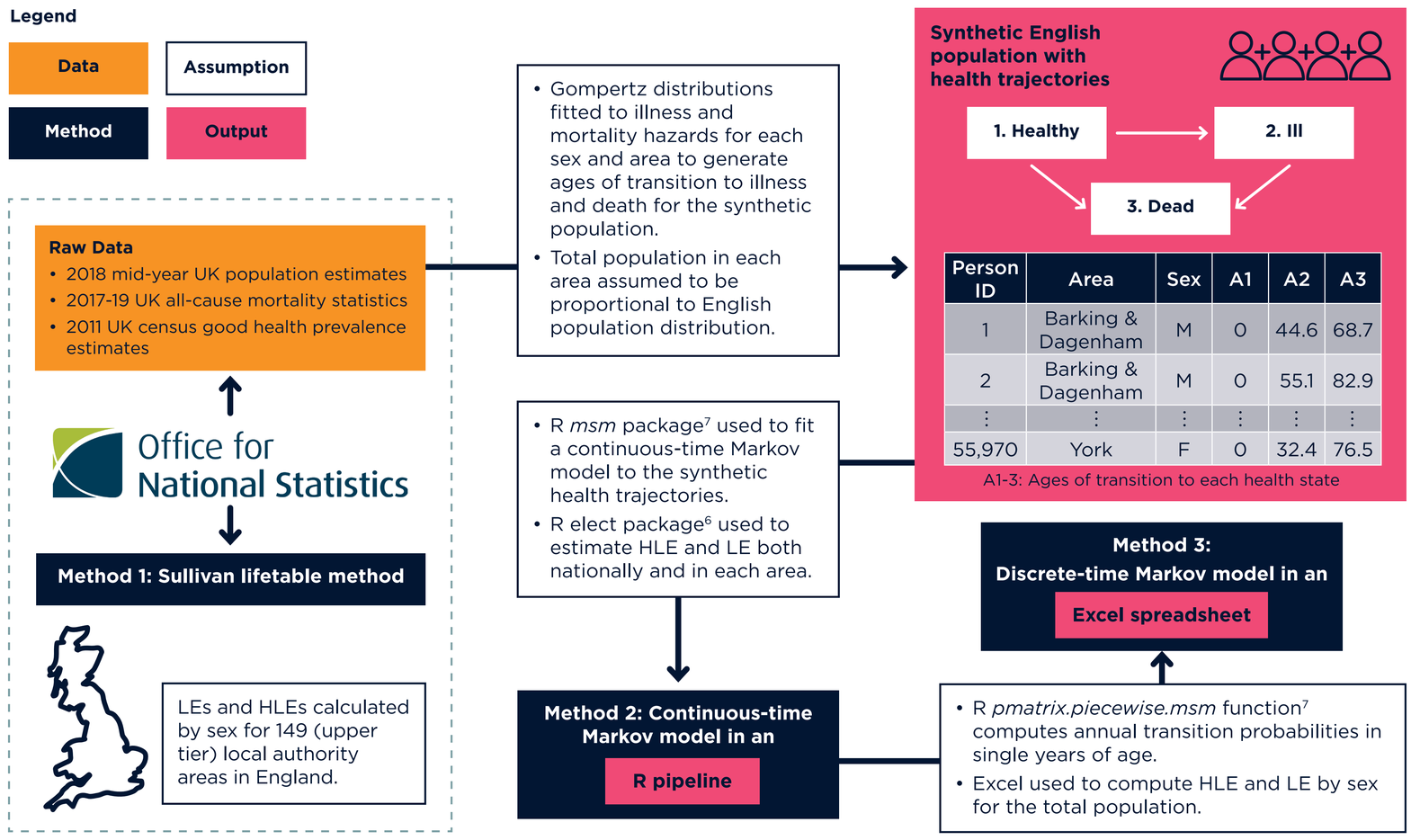
Method 2: Continuous-time Markov models

- Continuous-time Markov models use longitudinal data to estimate transition probabilities between health states[5,6].
- Any state structure can be used, with the 3-state illness-death model (Figure 1) one of the simplest[6].
- Although data requirements are greater, these models provide a better indication of health expectancy over time given current mortality and morbidity conditions[1,5].
- This type of model also allows for hidden transitions, not explicitly included in the state structure of the model, based on observations in the data[6]. This is especially useful for HLE estimation as the transition to ill health is based on self-reported outcomes so sometimes these transitions could be missed.

Method 3: Discrete-time Markov models

- Discrete-time Markov models estimate HLEs using transition probability matrices between health states for discrete ages.
- These are simpler to implement than continuous-time models and are commonly used in health economic evaluations.

Figure 1: Project methodology summary



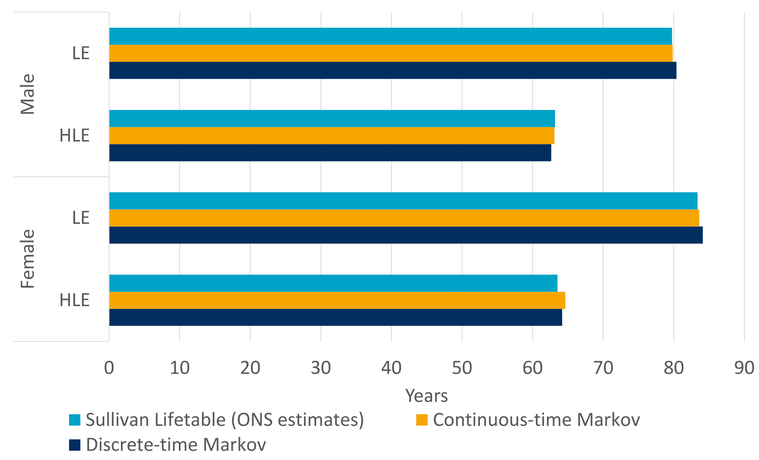
Results

- The synthetic population showed similar distributions of ages at illness and death as the ONS-reported estimates: 99.5% of the R-squared values calculated for the fitting of the Gompertz distributions were larger than 0.8 for both the male and female estimates in each local area, suggesting a good fit of distributions.
- Continuous-time Markov model estimates of mean LEs/HLEs for the synthetic population were 79.8/63.1 for men and 83.6/64.6 for women.
- The percentage differences compared with the ONS estimates using the Sullivan lifetable method were small (+0.1%/-0.1% for men and +0.3%/+1.8% for women) and estimates for 99% of local authorities were within +/-10% of the ONS estimates.
- When comparing the discrete- vs continuous-time Markov model estimates of LEs/HLEs, these were also similar: 80.4/62.6 (+0.7%/-0.7%) for men and 84.1/64.2 (+0.6% /-0.7%) for women.

Table 1: Percentage difference in LE and HLE estimates between methods

Sex	Continuous-time Markov vs Sullivan Lifetable (ONS estimates)		Discrete-time Markov vs Continuous-time Markov	
	LE	HLE	LE	HLE
Male	+0.10%	-0.15%	+0.68%	-0.71%
Female	+0.29%	+1.77%	+0.60%	-0.70%

Figure 2: Estimated LEs and HLEs under each method



Limitations/ Further research

- Recent health survey data used to supplement census responses in ONS HLE calculations are not readily available in an easily accessible format, so census data alone are used to inform transitions to ill health.
- Illness defined using self-reported good health may not be representative of an individual's true health state. While continuous-time Markov models allow for hidden transitions, exploring other definitions of ill health or in specific disease areas may be beneficial.
- Given trajectories are simulated from birth, the model could be refined to explore backwards transitions from ill to healthy, especially if illness occurs at younger ages.

Conclusions

- We have generated a synthetic population for England that captures differences in HLE at local area level and is suitable for use in evaluation studies.
- The continuous-time and discrete-time Markov models fitted to the synthetic population both replicated ONS Sullivan life table method estimates of HLEs and LEs well. This demonstrates the interoperability of these three methods and offers flexibility for researchers.
- The approach used to generate the synthetic population and estimate HLEs could equally be applied to future research in other populations with chronic diseases or in other countries.

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