Overview of multi-state life table methods

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Outline

♦ Data – cross-sectional v longitudinal
♦ Longitudinal methods
  – Strengths and limitations
  – Software
Cross-sectional versus longitudinal data
Assumptions

- All methods assume an underlying Markov process
  - probability that a person will leave a state depends only on the state and the person's age
  - ignores how long already had state
  - ignores previous history of transitions into and out of state
The simplest method of calculating a health expectancy is Sullivan’s method (Sullivan 1971) with:
- prevalence of the health state from a cross-sectional survey
- a standard life table for the same period

Multi-state life tables require longitudinal data
- use incidence rates
HE with cross-sectional data

Mortality data

Life table

Life expectancy

Age specific prevalence of ill-health (e.g. disability)

LE free of disability

LE with disability
HE with longitudinal data

Baseline

No disability
Disability

Follow-up

No disability
Disability
Dead
X-sectional versus longitudinal

♦ Cross-sectional
  + easiest for trends
  - life tables not available for subgroups

♦ Longitudinal
  + explicitly estimates incidence and recovery providing better future forecasts
  - cost, attrition
Prevalence v incidence

Disability prevalence

Incidence

Recovery

Death
Longitudinal methods
Longitudinal methods

- Multiple decrement
  - Non-reversible processes only
- Multi-state methods
  - Allows for transitions to and from all states
  - One absorbing state (death)
- Microsimulation
Multiple decrement

Baseline

- No disability
- Disability

Follow-up

- No disability
- Disability
- Dead
Multiple decrement methods

♦ Special case of multi-state methods
♦ Used for
  – Historically to calculate Active Life Expectancy (Katz, 1983)
  – Mortality by cause
  – Conditions where recovery impossible
    • heart attack, stroke,
    • dementia/cognitive impairment (though scales often blunt so improvements may be observed)
Longitudinal methods

♦ Multiple decrement
  – Non-reversible processes only

♦ Multi-state methods
  – Allows for transitions to and from all states
  – One absorbing state (death)

♦ Microsimulation
Multi-state methods

- Multi-state life table developed in 1970s
  - Allows changes in any direction
  - People can experience recurrent events over lifetime
  - Moves do not have to be to adjacent state
  - Can provide estimate of number of transitions over lifetime (but beware)
  - Aids understanding of role of declines and improvements in health
Multi-state methods

♦ Theoretically use age-specific transfer rates and applies them to hypothetical cohort
  – number of moves from state i to state j between ages x and x+n divided by person-years lived in state i between ages x and x+n
  – refers to moves not people

♦ Practically use (smoothed) age-specific transition probabilities
  – assumed constant within an age interval
Strengths and limitations

♦ Strengths
  – More realistic
  – Can incorporate covariates
  – Can use standard statistical software

♦ Limitations
  – Require longitudinal data for incidence rates
  – Data used not aimed at observing transitions
  – Transitions implicit between waves therefore may underestimate number of transitions as only one assumed between waves
Longitudinal methods

♦ Multiple decrement
  – Non-reversible processes only

♦ Multi-state methods
  – Allows for transitions to and from all states
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♦ Microsimulation
Microsimulation

♦ Microsimulation methods

- Use embedded Markov process to estimate rates (Laditka and Wolf, 1998; Lievre et al, 2003)
- The elementary transition is modeled as a multinomial logistic thus assuming an individual is in state j at age $x_i$ and state k after a time $h$ then

$$
\log\left[\frac{p_{jk}(x_i, x_i+h)}{p_{jj}(x_i, x_i+h)}\right] = a_{jk}(h) + b_{jk}(h)x_i
$$

- Transition matrix between two waves is the product of the elementary matrices (by month)
- Each person then subjected to given probability of event to simulate healthy life biography
Strengths and limitations

♦ Strengths
  – Allows for unequal intervals between waves and missing data
  – Relaxes assumption of only one transitions between waves
  – Purpose built software (IMaCH) available

♦ Limitations
  – Computationally intensive
  – Limited number of covariates
Example

Educational differences in the dynamics of disability incidence, recovery and mortality: Findings from the MRC Cognitive Function and Ageing Study (MRC CFAS)

Carol Jagger, Ruth Matthews, David Melzer, Fiona Matthews, Carol Brapa and MRC CFAS

Accepted: 16 December 2006

Background
This study aims to establish the extent of educational differences in the disability transitions of incidence, recovery and mortality in people aged 65 years and over, to elucidate whether these are influenced by differences inmobility, mobility, and their relative contribution to educational differences in prevalence and disability-free life expectancy (DFLE).

Methods
A stratified random sample of 1500 participants in five areas in England and Wales were interviewed in 1991–94 and followed up at 2, 4, 6 (one site only) and 10 years. Two levels of disability were analysed: mobility difficulty and activities of daily living (ADL) disability. We fitted logistic regression models to model educational differences in disability prevalence, incidence, recovery and mortality transitions. DFLE was calculated to assess the combined effect of the different transitions.

Results
Those with ≤9 years education had higher ADL and mobility disability prevalence and higher incidence and lower recovery of mobility disability. Differences in disability incidence remained after adjustment for socioeconomic status. Those with the lowest education had shorter life expectancies (1.7 years less at the age of 65 years) than the most educated and had shorter DFLE (1.9 years) of ADL disability and 2.8 years free of mobility disability at the age of 65 years.

Conclusions
Differences in education continue to contribute to prevalence of disability at age 65 years, with those with lower education having the highest disability in the future. These appear to be driven predominantly by differences in disability incidence that also compound to produce greater differences in DFLE between education groups than in total years lived.

Keywords
MRC CFAS, socioeconomic factors, disability, old age, self-report, activities of daily living

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Introduction
The nature of the links between less privileged socio-economic status and health has been extensively studied in middle aged populations, but relatively less so in older people, especially in the UK. For mortality, strong links have been demonstrated between socio-economic status and overall survival in older people. Higher prevalence rates of disability (having difficulty undertaking everyday activities) have also been linked to
MRC CFAS

- Five centres
- stratified random sample aged 65+
- includes those in institutions
- 13004 interviewed at baseline in 1991
- 2, 6 (Cambridge only) and 10 year follow-ups
- death information from ONS
Social inequalities at age 65

Mobility DFLE at age 65

<table>
<thead>
<tr>
<th>Years of education</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>12+</td>
<td>7.4</td>
<td>3.2</td>
</tr>
<tr>
<td>10-11</td>
<td>11.8</td>
<td>4.1</td>
</tr>
<tr>
<td>0-9</td>
<td>10.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Expected years of life

dfle dle
Mobility disability transitions OR* (95% CI)

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Incidence</th>
<th>Recovery</th>
<th>Mortality from disability free</th>
<th>Mortality from disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,11 yrs</td>
<td>GREEN</td>
<td>2.5</td>
<td>10,11 yrs</td>
<td>0-9 yrs</td>
</tr>
<tr>
<td>0-9 yrs</td>
<td>RED</td>
<td>2</td>
<td>0-9 yrs</td>
<td></td>
</tr>
</tbody>
</table>

*adjusted for age, comorbidity, MMSE

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