e-Labs and the Stock of Health Method for Simulating Health Policies

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Objectives

• Develop realistic models of disease that can be used to appraise health policy options
• Develop an approach that allows disease models to be used with regional data
• Use emerging technology to allow rapid and collaborative development of models
Stock of Health

- Max
- Clinical Event
- Stock of Health

- Birth
- Childhood
- Young adult
- Middle age
- Old age

- Artery
- Atheroma
- Thrombosis

- Typical course
- Prevention
- Adverse Risk Factors
SoH model

The Stock of Health lost in year $t$ ($\eta_{i,t}$) is modelled by

$$\log(\eta_{i,t}) = \beta_0 + \gamma_i + \beta_X X_i + \beta_Z Z_{i,t}$$

- $\beta_0$ = baseline rate of decline
- $\gamma_i$ = random element
- $X_i$ = age invariant risk factor levels
- $Z_{i,t}$ = age variant risk factor levels
- $\beta_X, \beta_Z$ = risk factor coefficients
Interventions

- When a risk factor shift occurs, an instant change in the SoH is allowed at the time of the shift.
Coronary Heart Disease Models

- Significantly contributes to health inequalities (3 fold higher in most deprived groups)\(^2\)
- 40% of CVD deaths attributed to coronary heart disease\(^1\)

• Stock of Health models for Coronary Heart Disease in England and Wales, UK
  - Mortality
  - Incidence
  - 5 risk factors: SBP, Cholesterol, BMI, smoking, diabetes

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Model fitting

- Data from the Prospective Studies Collaboration
  - Parameters determined by matching simulated hazard or odds ratios for risk factor shifts
- Nelder-Mead optimisation
England and Wales, UK

- Baseline rate of decline and random element
- Baseline rate of decline and random element optimised for the UK England and Wales population
  - Ischemic heart disease mortality data from the UK Office of National Statistics
  - Risk factor distributions from Health Survey for England

  - Minimised the distance between:
    - The observed and simulated: total and age group specific number of CHD deaths (1985 – 2010)
    - The mean and variance of the age at CHD death (1993 –
Calibration E&W

-5 mmHg shift in SBP

CHD Deaths (2001 cohort)

Baseline
Expected
Simulated

ONS Males
Simulated Males
ONS Females
Simulated Females

Calendar Year

Coronary Heart Disease Deaths

25 - 44
45 - 54
55 - 64
65 - 74
75 - 84

Age group
GPU Acceleration

Host

Compute device

Compute unit

Processing elements

Compute unit

Processing elements

Birth cohort
Information Design
Conclusion

• We have presented:
  – A flexible modelling methodology (SoH) that enables health policy to be appraised using local health data
  – A software engineering approach using GPU hardware to accelerate simulations
  – An information architecture that makes it simpler to develop, share and re-use digital artefacts across social networks of health professionals
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\( \beta_0 \) = baseline rate of decline
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SoH Jump (2)

- The instant change $\delta_t$ caused by an intervention which shifts a risk factor by $\Delta_t$ is given by

$$\delta_t = \alpha_j \Delta_t y_t^{p_{1,j}} (y_0 - y_t)^{p_{2,j}}$$

- $\alpha_j$ and the exponents $p_{1,j}$ and $p_{2,j}$ are determined through model fitting.
Performance

• Used Computational Shared Facility at the University of Manchester
  – NVIDIA Tesla C2050 devices
  – Scientific Linux 5.5
  – NVIDIA CUDA toolkit 4.0.17

• Life course of all males born in England and Wales, UK between 1901 and 2010
  = 40 x $10^6$ individuals
  = 0.5s