

Mind the Gap: A Study of Causal Mortality by Socio-Economic Circumstances

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Differences in life expectancy between the lowest and the highest socioeconomic categories have widened over past decades in several countries (Brønnum-Hansen and Baadsgaard [2012]).

Recent observations



(a) Age 25



(b) Age 65

Figure: Life expectancy, England, females

Recent observations

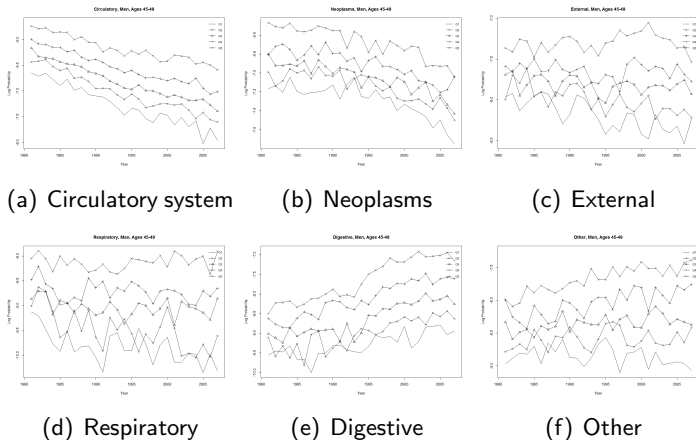


Figure: Log-mortality over time, England, males

Aim

What? Develop a tool that would help policy decisions aiming at reducing differences in life expectancy between socioeconomic categories.

How? By developing a model which takes into account the main causes of death for each socioeconomic category.

Key questions:

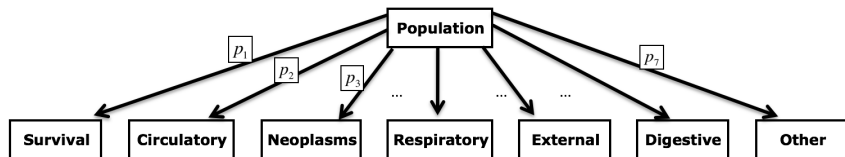
→ Which scenario of cause-elimination would help to reduce the gap?

→ Which scenario of cause-elimination would help to close the life expectancy gap while achieving the highest overall increase in life expectancy across the society?

Data

- ▶ 1981-2007, England by socioeconomic circumstances (SEC) quintiles.
 - Mortality counts from ONS.
 - Population estimates from Dr Paul Norman, Leeds University.
- ▶ Inequalities by SEC: census areas grouped into quintiles by increasing deprivation (IMD 2007)
 - Q1 = least deprived.
 - Q5 = most deprived.
- ▶ Causes-of-Death (CoD) - adjusted for ICD change using ONS bridge coded dataset 1999: diseases of the circulatory system; neoplasms; diseases of the respiratory system; external causes; digestive causes; other.

Multinomial logit models



- ▶ Typically used for a response with several unordered categories (Alai et al. [2015]).

Multinomial logit models

$$\begin{aligned} \log \left(\frac{q_1(x, t, g, s)}{p(x, t, g, s)} \right) &= a_{x,g,s}^{(1)} + b_{x,g}^{(1)} \cdot t + c_{x,g}^{(1)} \cdot t^2 + e_{g,s}^{(1)} \cdot t + f_{g,s}^{(1)} \cdot t^2 \\ &= Y^{(1)}(x, t, g, s) \end{aligned}$$

$$\begin{aligned} \log \left(\frac{q_2(x, t, g, s)}{p(x, t, g, s)} \right) &= a_{x,g,s}^{(2)} + b_{x,g}^{(2)} \cdot t + c_{x,g}^{(2)} \cdot t^2 + e_{g,s}^{(2)} \cdot t + f_{g,s}^{(2)} \cdot t^2 \\ &= Y^{(2)}(x, t, g, s) \end{aligned}$$

...

$$\begin{aligned} \log \left(\frac{q_6(x, t, g, s)}{p(x, t, g, s)} \right) &= a_{x,g,s}^{(6)} + b_{x,g}^{(6)} \cdot t + c_{x,g}^{(6)} \cdot t^2 + e_{g,s}^{(6)} \cdot t + f_{g,s}^{(6)} \cdot t^2 \\ &= Y^{(6)}(x, t, g, s) \end{aligned}$$

The *logit* probabilities depend on a set of factors: the age, the gender, the SEC and a period effect.

Multinomial logit models

By definition of the logit function, we have

$$q_i(x, t, g, s) = \frac{\exp\{Y^{(i)}(x, t, g, s)\}}{1 + \sum_k \exp\{Y^{(k)}(x, t, g, s)\}}, \quad i = 1, \dots, n$$
$$p(x, t, g, s) = \frac{1}{1 + \sum_k \exp\{Y^{(k)}(x, t, g, s)\}}.$$

Shocks in the multinomial model

$$q_i(x, t, g, s) = \frac{\rho_i \exp\{Y^{(i)}(x, t, g, s)\}}{1 + \sum_k \rho_k \exp\{Y^{(k)}(x, t, g, s)\}}, \quad i = 1, \dots, n$$
$$p(x, t, g, s) = \frac{1}{1 + \sum_k \rho_k \exp\{Y^{(k)}(x, t, g, s)\}},$$

with $\rho_i \geq 0$, a shock applied to cause i .

→ Assume independence

Do we have a good fit?

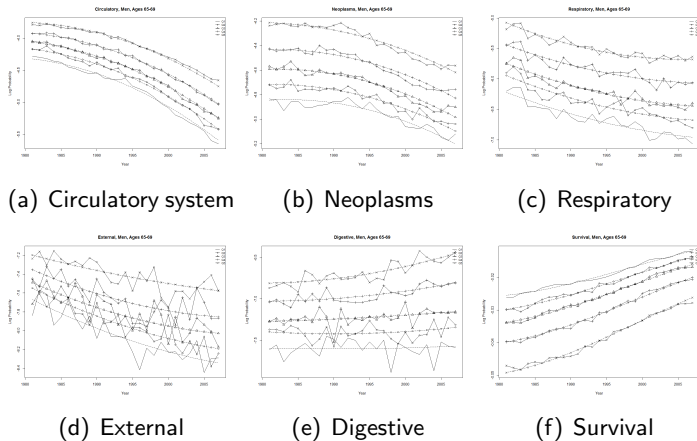


Figure: Observed and fitted values of mortality rates, age-group 65-69, England, males

Do we have a good fit?

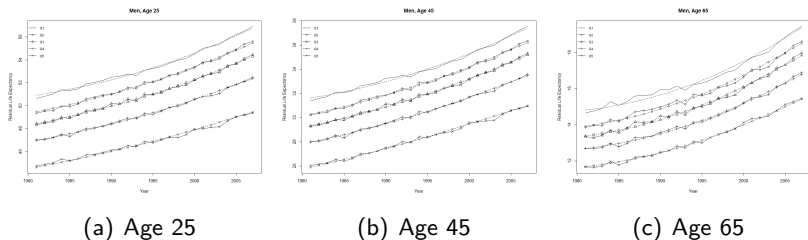


Figure: Observed and fitted life expectancies, England, males

Which scenario of cause-elimination would help to reduce the gap?

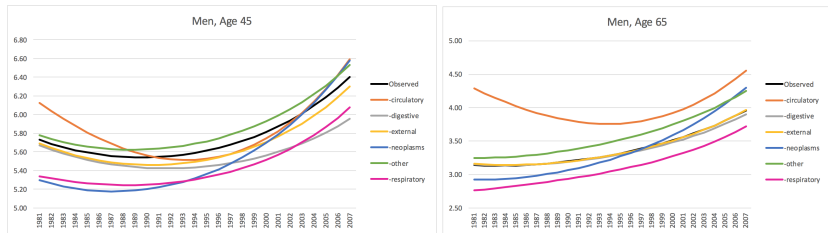


Figure: Gaps in life expectancy between the highest and lowest socio-economic categories, England, males, ages 45 and 65

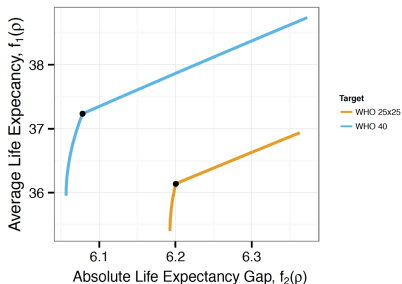
Which scenario of cause-elimination would help to close the life expectancy gap while achieving the highest overall increase in life expectancy across the society?

WHO NCD Global Monitoring Framework 2025 target: Overall reduction in premature mortality by 25%, from cardiovascular disease, chronic respiratory disease, diabetes and neoplasms.

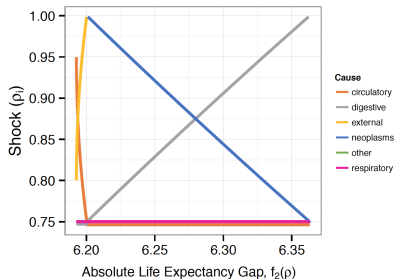
→ Is it the optimal strategy?

→ Multi-objective optimisation approach

Which scenario of cause-elimination would help to close the life expectancy gap while achieving the highest overall increase in life expectancy across the society?



(a) Pareto Front



(b) Optimal policies WHO 25x25

Figure: Optimal strategies for males age 45

Concluding remarks

- ▶ We provide a basis to assist government bodies in implementing well-informed strategies aimed at reducing social inequalities.
 - Use cause-specific mortality data by deprivation categories.
 - Use the multinomial logit model developed by Alai et al. [2015] → extend it to allow for socio-economic covariates.
 - AND** an optimisation procedure → simultaneously maximises overall gain in life expectancy whilst minimising social inequalities.

Concluding remarks

Key findings:

- ▶ Decline in heart disease mortality:
 - Major contributor to increases in life expectancy
 - BUT also increases inequalities.
- ▶ The optimal cause-of-death to target in order to reduce life expectancy gaps changes over time.
 - Crucial to take into account the latest time trends.
- ▶ To reduce inequalities, respiratory diseases need to be targeted as a priority.
- ▶ WHO target increases inequalities for men
 - A more optimal solution would be to target digestive diseases instead of neoplasms.

Next step: Include a budget constraint.

Bibliography

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Thank you very much for your
attention!

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