The impact of differences in patient demographics on assessment of long-term cost-effectiveness in cohort level economic models

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SUMMARY

OBJECTIVES

- Health economic modelling is a key component to showing that new treatments represent good value for money to healthcare payers.
- Economic modelling often makes assumptions that help simplify the problem and make constructing a model more straightforward.
- A common assumption in cohort models is that many mean cohort characteristics are assumed to be fixed over time, such as sex, however, different rates of mortality in males and females mean that the composition of the cohort will change over time.
- This study aimed to quantify the impact of this assumption on patient health outcomes.

METHODS

- We developed a lifetime health economic model that would predict health outcomes for a UK general population, in terms of life-years and quality-adjusted life years gained.
- The modelled cohort were assumed to have average health-related quality of life, adjusted for age and sex.
- Two analysis approaches were assessed, one assuming that the cohort had a fixed sex composition of 50% males and females, and one approach that accurately reflected the changing proportions of males and females over time.

FINDINGS

- We found that the typical modelling assumption of fixed baseline cohort demographics systematically underestimated patient health outcomes in terms of life years and quality-adjusted life years gained, in comparison with a more granular and representative approach to the analysis.
- This means that health economic models that make this assumption may underestimate the benefits of treatment, with the potential to lead to incorrect conclusions of cost-effectiveness.
- The impact of this should be considered when building health economic models, particularly in analysis conducted over long time horizons.

BACKGROUND & AIMS

- Health economic modelling is fundamental to assessing the cost-effectiveness of new interventions and determining the efficient allocation of healthcare resources.
- Health economic models often consider the patient population to be a single cohort with fixed average patient demographics as a simplifying assumption.
- However, demographics such as sex can have a significant impact on patient outcomes and so average demographics may change over time.
- Consequently, this will impact the number of life-years (LY) and quality-adjusted life years (QALY) accrued over time when comparing a modelled population with fixed patient demographics and one with realistic, time-updated patient demographics.
- This also has the potential to impact health outcomes linked to patient demographics, such as the risk of developing cardiovascular disease.
- **The objective of this study was to quantify the impact of modelling survival stratified by sex in comparison with a typical approach assuming fixed average patient demographics.**

METHODS

- A lifetime model was developed to assess population outcomes in terms of LYs and QALYs gained in a UK general population.
- The modelled population were assumed to be a mean age of 18 years old at baseline, with patients age normally distributed assuming a standard deviation of 5 years, with additional analysis conducted for patients with different baseline ages.
- The modelled cohort was assumed to be 50% female at baseline.
- Survival was modelled using UK life table estimates.[1]
- QALYs gained was estimated using published sex specific EQ-5D population norms.[2]
- Two scenarios were assessed:
  - **Fixed distribution of patient demographics:** a single cohort with a fixed distribution of sex (50% male, 50% female) with a weighted average utility and mortality risk
  - **Time-updated patient demographics:** a patient cohort where outcomes for each sex were assessed independently, and then aggregated.

Figure 1. Mean patient sex demographics over time.

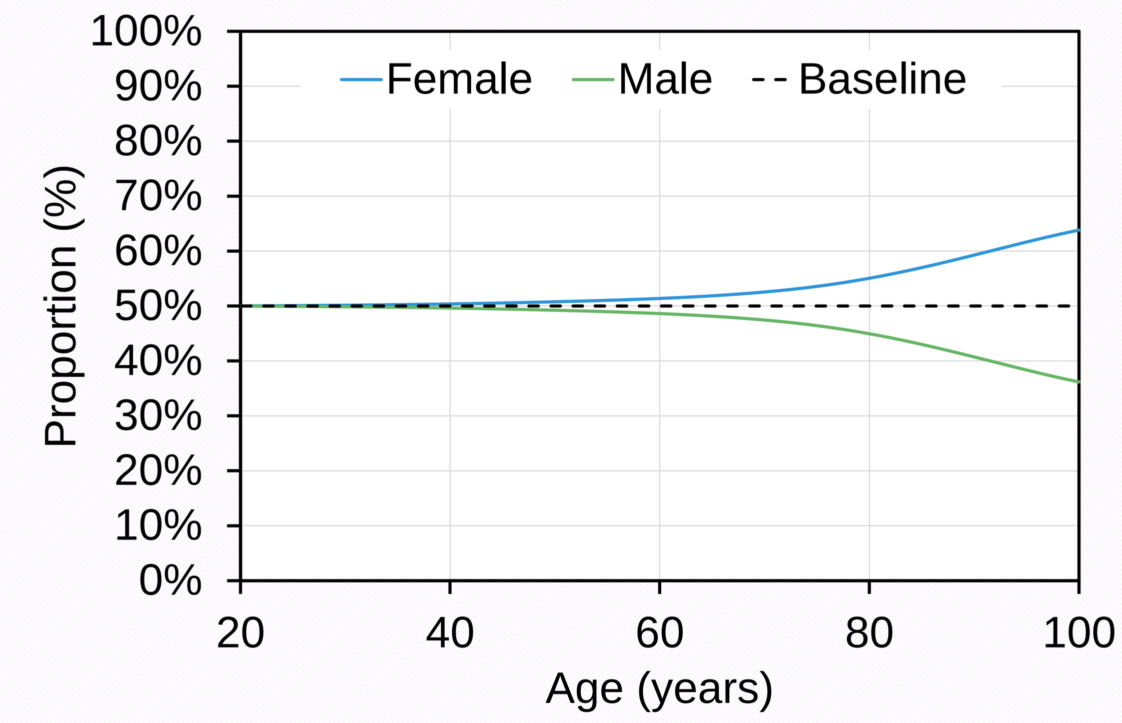
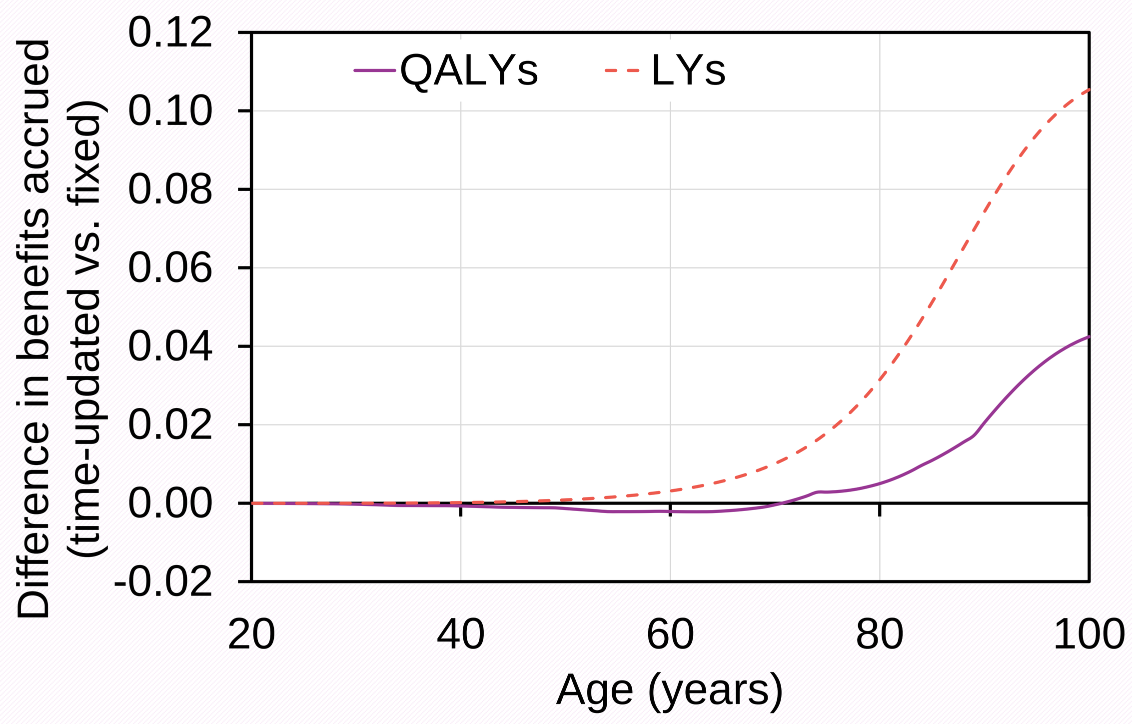


Figure 2. Mean difference in benefits accrued over time.



RESULTS

- When modelling outcomes for males and females separately, the proportion of females in the surviving cohort changed from 50% at baseline, to 63.8% at age 100 because of different mortality risk for males and females. (**Figure 1**)
- Treating the modelled population as a single homogenous cohort with fixed average baseline characteristics resulted in a total LY gain of 62.21, translating to a QALY gain of 51.12 over a lifetime horizon.
- In comparison, modelling outcomes for males and females independently resulted in LY gains of 62.33, or an additional 0.11 LYs compared with fixed patient demographics, showing a systematic underestimation of patient survival when modelling using fixed baseline patient characteristics. (**Figure 2**)
- Increased estimated survival and sex specific utility estimates in the cohort with time-updated patient demographics translated to a QALY gain of 51.16, or an additional 0.05 QALYs gained compared with modelling fixed patient demographics.
- The difference between analysis methods is more influential in younger cohorts, with the estimated difference in LY gains reducing to 0.10 in a cohort aged 40 years old at baseline, and to 0.08 in a cohort aged 60 years old at baseline, translating to differences in QALYs gained of 0.04 and 0.03, respectively. (**Table 1**)
- The underestimation of benefits accrued when modelling the cohort with fixed patient demographic characteristics corresponds to a net monetary benefit of £1,385 at a willingness-to-pay threshold of £30,000/QALY.
- This systematic underestimation has the potential to results in incorrect conclusions regarding cost-effectiveness.

Table 1. Lifetime benefits accrued by baseline age.

Patient baseline age	LYs			QALYs			
	Fixed demographics	Updated demographics	Difference	Fixed demographics	Updated demographics	Difference	NMB (£30,000/QALY)
18 years	62.21	62.33	0.111	51.12	51.16	0.046	£1,385.30
30 years	50.60	50.71	0.106	40.85	40.90	0.044	£1,331.44
40 years	41.20	41.30	0.099	32.58	32.62	0.042	£1,246.62
50 years	32.19	32.27	0.089	24.99	25.02	0.038	£1,125.24
60 years	23.61	23.69	0.077	18.00	18.03	0.032	£967.94

Abbreviations: LYs, life years; NMB, net monetary benefit; QALYs, quality-adjusted life years.

LIMITATIONS

- This analysis only considered the impact of sex on patient outcomes; however, the same assumption is frequently made for other patient characteristics.
- Similarly, while this analysis considers survival and patient health related quality of life, these characteristics also impact other health outcomes such as the risk of developing morbidities including diabetes mellitus, cardiovascular disease, and chronic kidney disease.
- As such, the difference in accrued benefits calculated in this study may underestimate the potential impact of this systematic bias in practice.

CONCLUSIONS

- The choice of modelling approach has the potential to meaningfully impact estimated patient outcomes.
- Modelling patient populations using fixed mean baseline demographic characteristics systematically underestimates total benefits in terms of patient survival and QALYs gained.
- The scale of this underestimation increases in younger patient cohorts, and over longer time horizons.
- Modelling interventions under this assumption will underestimate incremental benefits associated with a new treatment, and may result in incorrect cost-effectiveness conclusions, and inefficient allocation of healthcare resources.
- The impact of this bias should be considered when conceptualising health economic models, particularly when used for analysis with long time horizons.

References

1. *Office for National Statistics. National life tables, United Kingdom: Reference tables. Office for National Statistics 2021.*
2. *McNamara S, Schneider PP, Love-Koh J, Doran T, Gutacker N. Quality-Adjusted Life Expectancy Norms for the English Population. Value Health. 2023;26(2):163-169. doi:10.1016/j.jval.2022.07.005*

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