A Distributional Cost-Effectiveness Analysis of Cervical Cancer Screening Strategies in England

van Hest N,[1] Griffiths M[1]
[1]Costello Medical, London, UK

EE48

OBJECTIVES

- To evaluate distributional impacts of different actual and hypothetical cervical cancer screening strategies on health differences by socioeconomic status and sex for England.
- To provide an informative case study for the implementation of the DCEA method for cervical cancer screening.

BACKGROUND

- Cervical cancer is the fourth-most common cancer affecting women globally, with an estimated 604,000 new cases in 2020.[1] Early diagnosis of cervical cancer (e.g. via population screening) substantially increases patient survival and curative ability of treatment.[1]
- Despite a decrease in related mortality since the introduction of the National Health Service (NHS) cervical screening program, screening coverage has been declining year on year. Lower screening attendance has been linked to ethnicity, deprivation, and age.[2]
- Economic evaluations of existing cervical cancer screening programs have demonstrated the cost-effectiveness of primary human papillomavirus (HPV) screening through consideration of average health gains and costs; however, such analyses have neglected consideration of the distributional impact on health (impact on health equity).[3]
- Distributional cost-effectiveness analyses (DCEA) represents a method to estimate the health equity impacts of healthcare interventions by estimating the distribution of health benefits and losses across social groups of interest.[4] For example, DCEA can be used to provide information to decision makers on the health equity impact of different screening strategies.

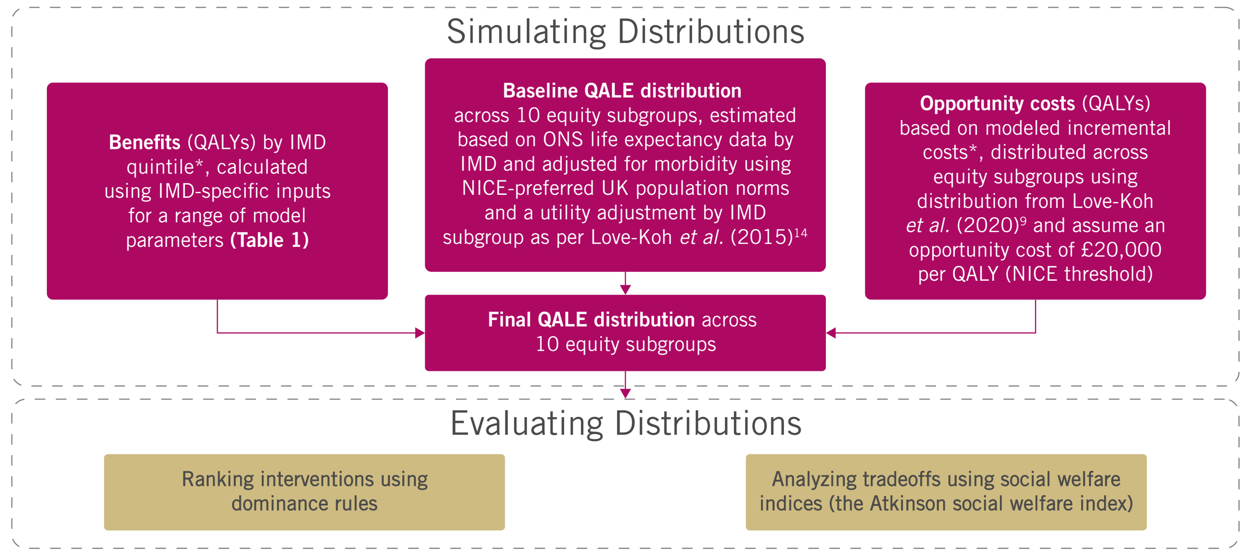
METHODS

- **Figure 1** summarizes the steps of the DCEA to determine the final distribution of health associated with adoption of each screening strategy. Distribution of health was calculated across 10 equity subgroups defined by combination of socioeconomic status (based on Index of Multiple Deprivation [IMD] quintiles) and sex (male/female).
- A cost-effectiveness analysis employing a decision tree and Markov model **(Figure 2)** was developed to estimate incremental costs and health benefits (quality-adjusted life years [QALYs]) over a lifetime for each cervical cancer screening strategy in England by IMD quintiles (IMD1 to IMD5). The decision tree (not shown) was used to reflect the screening algorithm in the UK, using the HPV, Pap grade and cervical intraepithelial neoplasia (CIN) distribution within the population to capture costs and disutilities. Women could be triaged with follow-up cytology, or return to routine screening, after which they could be referred to confirmatory colposcopy for diagnosis and treatment (CIN2+; i.e. CIN2/3 or invasive cervical cancer) or for 1-year follow-up).
- The staircase of equality impact was considered in order to assess which model inputs could vary by IMD.[4] Based on data availability, the inputs outlined in **Table 1** were modeled as variable.
- Three actual or hypothetical cervical cancer screening strategies were compared to a baseline of 'no screening': 1) HPV screening, representing standard of care in the UK; 2) a hypothetical addition of HPV self-sampling; 3) a hypothetical targeted reminder for those in the two most deprived quintiles (IMD1 and IMD2).
- For evaluation of results, the level-dependent Atkinson social welfare function was implemented as per Asaria *et al.*[5] to estimate the equity-weighted health impact of each strategy under different levels of inequality aversion.

RESULTS

- Compared to no screening, all three strategies had a positive health impact but increased inequality.
- Self-sampling provided the largest population health gains compared to no screening but was also associated with the greatest negative impact on equity as assessed by the Atkinson index of inequality (A(ε)) **(Figure 3)**. Targeted reminder had the smallest negative equity impact.
- Incremental equity-weighted health was positive for all strategies compared to no screening at all explored levels of inequality aversion (ε between 0 and 30), but decreased as inequality aversion increased. The targeted reminder was associated with the greatest equity-weighted health provided inequality aversion was six or greater **(Figure 4)**; below this level, a self-sampling strategy was favored.
- Results did not vary greatly in key scenario analyses: 1) assuming equally distributed opportunity costs; 2) using the Claxton *et al.*[15] estimate for health opportunity costs of £12,936 per QALY.

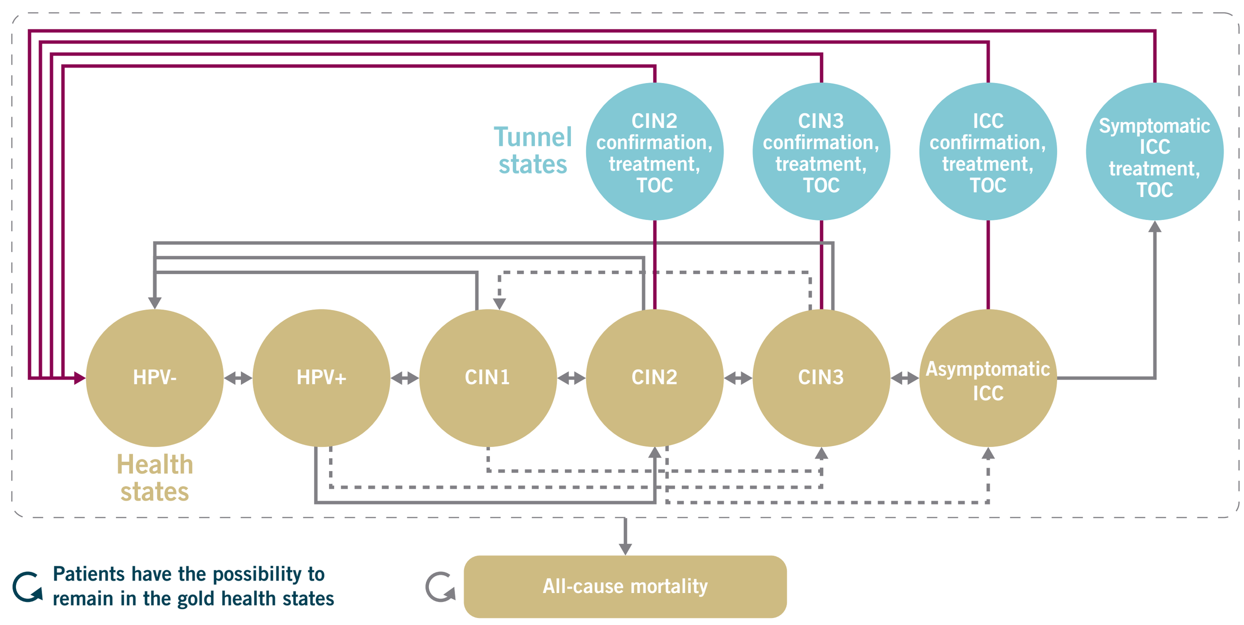
1 Steps of the DCEA



*Incremental benefits and costs (opportunity costs) were estimated by IMD subgroups (IMD1-IMD5) only, without the sex dimension, as cervical cancer screening strategies apply only to the female population. However, opportunity costs were distributed across all 10 equity subgroups (both deprivation and sex dimensions) as opportunity costs fall on both the male and female population. Figure adapted from Distributional Cost-Effectiveness Analysis: Quantifying Health Equity Impacts and Trade-Offs: Oxford University Press, 2020 (Figure 3.5).[4]

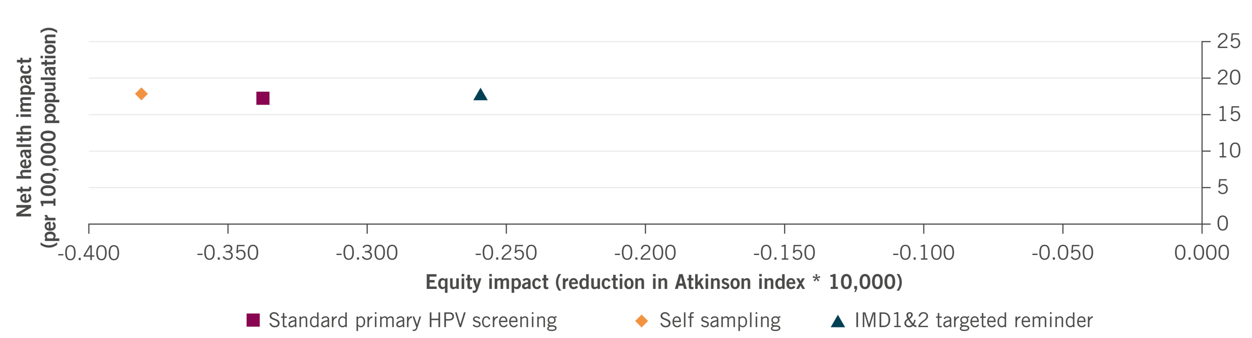
IMD: Index of Multiple Deprivation; **NICE:** National Institute for Health and Care Excellence; **ONS:** Office for National Statistics; **QALE:** quality-adjusted life expectancy; **QALY:** quality-adjusted life years; **UK:** United Kingdom.

2 Model structure



CIN: cervical intraepithelial neoplasia; **HPV:** human papilloma virus; **ICC:** invasive cervical cancer; **TOC:** test of cure.

3 Equity-efficiency impact plane comparing the screening strategies[a,b]



[a]The results displayed in the above figure (for both axes) are incremental results compared to the baseline of no screening. [b]The base-case Atkinson inequality aversion parameter (ε) used in this analysis was 10.

HPV: human papilloma virus; **IMD:** Index of Multiple Deprivation.

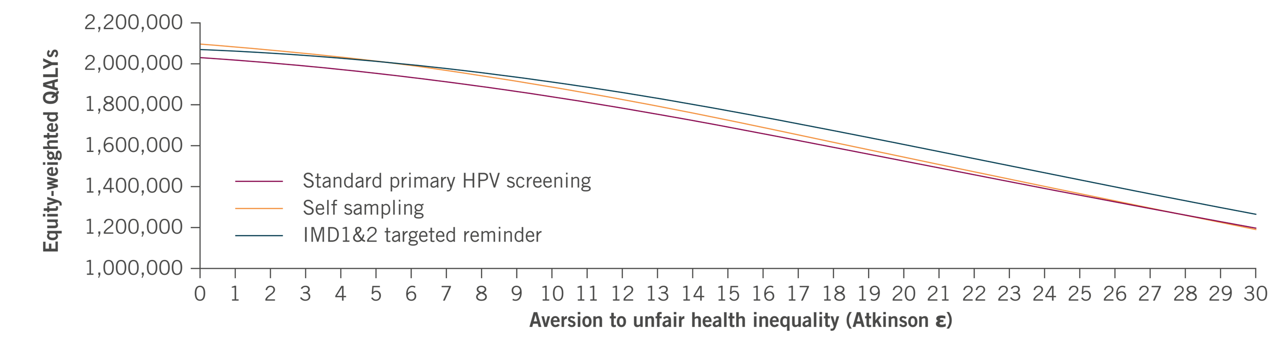
1 Model inputs by IMD group

	IMD1	IMD2	IMD3	IMD4	IMD5	Source
Disease prevalence at baseline						
hr-HPV–, (%)	81.70	81.70	85.00	86.50	86.50	Tanton *et al.* 2015[6]
hr-HPV+, (%)	13.40	13.08	9.96	9.24	9.06	All patients with CIN/ICC are assumed as HPV+
Borderline, (%)	1.36	1.33	1.22	1.13	1.12	NHS Cervical Cancer Screening Programme 2020–21: Age Group 25–64[7]
CIN1, (%)	2.19	2.61	2.60	2.13	2.28	
CIN2, (%)	0.63	0.66	0.61	0.49	0.53	
CIN3, (%)	0.63	0.54	0.54	0.44	0.44	NHS Digital Cancer Registration Statistics, England 2019[8]
ICC, (%)	0.08	0.07	0.07	0.07	0.06	
HSUVs[a]						
Age-related utilities	0.8595–0.5538	0.8953–0.5768	0.9094–0.5859	0.9322–0.6006	0.9539–0.6145	HSE 2014, IMD-adjusted using adjustment from Love-Koh *et al.* 2019[9,10]
Compliance to screening by strategy[b]						
Current screening, (%)	67.89–72.99	65.86–73.39	66.73–72.55	70.69–75.19	70.89–76.16	NHS Cervical Cancer Screening Programme 2020–21[7]
Self-sampling, (%)	78.33–82.21	76.64–82.51	77.42–81.88	80.48–83.83	80.63–84.83	Based on Musa *et al.* 2017, an odds ratio of 1.71 was applied to current screening rates to estimate compliance[11]
IMD 1&2 targeted screening, (%)	79.89–84.99	77.86–85.39	66.73–72.55	70.69–75.19	70.89–76.16	Based on Asaria *et al.* 2015, it was assumed that IMD1 and IMD2 had a 12% increase in compliance compared to current primary HPV screening[12]
Mortality						
Mortality by ICC stage						
FIGO I, (%)	1.70	1.63	1.60	1.59	1.57	1-year ICC survival was adjusted for each IMD quintile using survival estimates from NHS cancer data for female cervical cancer patients
FIGO II, (%)	6.39	6.12	6.00	5.96	5.90	
FIGO III, (%)	22.99	22.03	21.60	21.47	21.24	
FIGO IV, (%)	53.96	51.70	50.70	50.40	49.86	
Background mortality[c], (%)	0.04–25.90	0.02–23.81	0.02–22.72	0.03–22.22	0.02–20.95	ONS 2020, female mortality by IMD[13]

[a]The range given for age-related utilities is for each age between 25 and 100. [b]The range given for compliance to screening is for two age intervals: 25–49 and 50–64. [c]The range given for background mortality is for each age between 25 and 100.

CIN: cervical intraepithelial neoplasia; **FIGO:** International Federation of Gynecology and Obstetrics; **HPV:** human papilloma virus; **HSE:** Health Survey for England; **HSUV:** Health State Utility Value; **ICC:** invasive cervical cancer; **IMD:** Index of Multiple Deprivation; **NHS:** National Health Service; **ONS:** Office for National Statistics.

4 Population-level difference in EDEH of different screening strategies[a]



[a]The base-case Atkinson inequality aversion parameter (ε) used in this analysis was 10.

EDEH: equally-distributed equivalent health; **HPV:** human papilloma virus; **IMD:** Index of Multiple Deprivation; **QALY:** quality-adjusted life year.

CONCLUSIONS

- Cervical cancer screening strategies were found to be associated with a trade-off between health benefits and increased inequality.
- The DCEA allowed for the identification and evaluation of this trade-off and this exploratory analysis indicated that a hypothetical targeted reminder strategy has potential to mitigate equity impacts.
- Key limitations/assumptions of the analysis include: 1) screening compliance data from NHS Digital were only available by local authority, requiring mapping between local authority and IMD; 2) the model assumed no differences by IMD in the rate of progression of HPV to cervical cancer or costs associated with treatment at each stage; 3) model inputs by IMD were informed by targeted rather than systematic searches; 4) the estimate for the impact on compliance of the hypothetical targeted reminder strategy had to be assumed to be equivalent to that observed in bowel cancer.

References

1. Sung H, Ferlay J, Siegel RL, *et al.* Global Cancer Statistics 2020: GLOBOCAN Estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2021;71:209–249; **2.** Public Health England. Health matters: making cervical screening more accessible. Available at: https://www.gov.uk/government/publications/health-matters-making-cervical-screening-more-accessible/health-matters-making-cervical-screening-more-accessible--2. [Last accessed March 2023]; **3.** H CK, Canfell K, Gilham C, *et al.* The clinical effectiveness and cost-effectiveness of primary human papillomavirus cervical screening in England: extended follow-up of the ARTISTIC randomised trial cohort through three screening rounds. Health Technol Assess 2014;18:1–196; **4.** Distributional Cost-Effectiveness Analysis: Quantifying Health Equity Impacts and Trade-Offs: Oxford University Press, 2020; **5.** Asaria M, Griffin S, Cookson R. Distributional Cost-Effectiveness Analysis: A Tutorial. Med Decis Making 2016;36:8–19; **6.** Tanton C, Soldan K, Beddows S, *et al.* High-Risk Human Papillomavirus (HPV) Infection and Cervical Cancer Prevention in Britain: Evidence of Differential Uptake of Interventions from a Probability Survey. Cancer Epidemiol Biomarkers Prev 2015;24:842–53; **7.** NHS Digital. Cervical Screening Programme, England - 2020–21. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/cervical-screening-annual/england--2020-2021. [Last accessed April 2023]; **8.** NHS Digitial. Cancer Registration Statistics, England 2019. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/cancer-registration-statistics/england-2019. [Last accessed April 2023]; **9.** Love-Koh J, Cookson R, Gutacker N, *et al.* Aggregate Distributional Cost-Effectiveness Analysis of Health Technologies. Value in Health 2019;22:518–526; **10.** NHS Digital. Health Survey for England, 2014. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2014. [Last accessed April 2023]; **11.** Musa J, Achenbach CJ, O'Dwyer LC, *et al.* Effect of cervical cancer education and provider recommendation for screening on screening rates: A systematic review and meta-analysis. PLOS ONE 2017;12:e0183924; **12.** Asaria M, Griffin S, Cookson R, *et al.* Distributional cost-effectiveness analysis of health care programmes--a methodological case study of the UK Bowel Cancer Screening Programme. Health Econ 2015;24:742–54; **13.** Office of National Statistics. Deaths registered in England and Wales: 2020. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregistrationsummarytables/2020. [Last accessed April 2023]; **14.** Love-Koh J, Asaria M, Cookson R, *et al.* The Social Distribution of Health: Estimating Quality-Adjusted Life Expectancy in England. Value Health 2015;18:655–62; **15.** Claxton K, Martin S, Soares M, *et al.* Methods for the Estimation of the NICE Cost Effectiveness Threshold. Health Technol Assess 2015;19(14):1–503.

Acknowledgements

The authors thank Jon Green, Costello Medical, for graphic design assistance. We also thank Sukanya Subramaniyan, Costello Medical, for her review and editorial assistance in the preparation of this poster, and for her guidance and support of this research.

Presented at ISPOR 2023 | Boston, MA, USA | 7–10 May

costello medical