Domain 3: Developing the economic case for lung cancer screening

For many clinicians, screening leads and implementation researchers, developing an economic case for screening may be a challenging and unfamiliar task. Table 1 can be used to identify which type of evaluation is most useful based on the information available or the outcomes that users would like to measure. While economic evaluations are complex and require additional data and expertise beyond what is included here, this resource serves as a useful starting point for clinicians, screening leads and implementation researchers interested in learning more about these types of evaluation.

There are several types of economic evaluation; they all synthesise information about patient health and associated costs[*] to inform decision-making. They differ in how they account for the costs and benefits of an intervention, which are then often set against a willingness-to-pay threshold,[†] which differs by country.[1]

Table 1. Different types of economic evaluations

Type of economic evaluation	What does it do?
Cost-effectiveness analysis[‡]	Calculates and compares the incremental cost-effectiveness ratios (ICERs) of different interventions; outcome measures are expressed in a single natural unit (such as life-years gained or quality-adjusted life years (QALYs)).[2]
Cost-utility analysis[‡]	A type of cost-effectiveness analysis that compares the cost and outcomes of different interventions. It uses a generic measure of health status, such as disability-adjusted life years (DALYs) or QALYs, to quantify the impact of interventions on both morbidity and mortality.[2]
Cost-benefit analysis	Compares the costs and benefits of different interventions in purely financial terms. Benefits are given a financial value.[2]
Budget impact analysis	Estimates the overall cost of implementing an intervention. It is typically conducted alongside cost-effectiveness analysis.[3] Budget impact analysis calculates the total budget needed by multiplying the unit cost of the intervention by the number of people who will benefit from it. This provides a clear understanding of the total financial requirement for funding.[3]

Why is perspective important?

The perspective is the point of view the economic evaluation considers. Depending on the perspective, the data on costs and effects that need to be captured differ,[4] so perspective can impact the results of the evaluation.[5] It shapes the analysis, ensures that relevant outcomes are considered, and ultimately influences the decision-making process regarding the healthcare intervention. Different perspectives reflect different priorities and can lead to distinct conclusions, so it is important to ensure that the perspective reflects the context of the country, the decision-maker and the question that the evaluation aims to answer.[5,6]

Some perspectives include:[4,7]

- healthcare payer
- national payer
- societal
- patient
- single payer

* A list of potential costs to consider for lung cancer screening programmes can be found here.

† Willingness-to-pay threshold: This helps determine whether a healthcare intervention is considered economically justified or worthwhile based on its costs and clinical effectiveness. It represents the maximum amount a decision-maker or policymaker is willing to spend to achieve a unit of health benefit (often measured in QALYs). The willingness-to-pay threshold varies by country, reflecting its economic context and health policy priorities.

‡ The distinction between cost-effectiveness and cost-utility analyses is often blurred in practice; as a result, cost-utility analyses are often referred to as cost-effectiveness analyses.[2]

What is needed to assess the cost-effectiveness of screening for lung cancer?

Decision-makers require an assessment of the cost-effectiveness of lung cancer screening and its impact on their budget before it can be implemented in practice.[1 8] Prior to completing a cost-effectiveness analysis, it is important to understand the information and data that will be needed to complete the analysis, so they can be collected (e.g. during implementation research or pilots). In some countries, national data may not be available, so understanding the necessary inputs can help inform the design and planning of pilot programmes or implementation research.

This resource provides an overview of various cost-effectiveness models that might be used to evaluate lung cancer screening interventions on a national/regional level. It highlights key parameters that should be included as well as different outcome measures that can be used to quantify the health benefits of screening.

Cost-effectiveness models

Cost-effectiveness models draw on information from various sources to analyse which interventions represent the best value. These models are a structured, objective way to assess the relative value of health interventions, guiding decisions that can lead to better health outcomes while ensuring financial sustainability in healthcare systems. The cost of a screening programme can be influenced by many factors, and it's important to gather data to inform economic models and financial planning. The costs of delivering screening may fluctuate over time, so models and forecasts should be regularly updated as additional data become available. Markov models, microsimulation models, natural history models and decision trees are all examples of cost-effectiveness models.

Markov model

Markov models are used to evaluate the effectiveness and cost-effectiveness of a health intervention. These models do not track individual histories; instead, they simulate the behaviour of a group of people as they transition through different states of health, following average disease progression and treatment patterns.

The states in a Markov model are essential for evaluating cost-effectiveness because they allow for the estimation of:

- transition probabilities (e.g. that someone will progress from one state to another)
- costs (e.g. of screening, follow-up tests, treatment and palliative care)
- outcomes (e.g. quality of life, survival).

For lung cancer screening, the model's states could be stages I, II, IIIA, IIIB and IV as well as 'death' and 'cured'.[9]

By modelling transitions, Markov models provide insights into how earlier detection achieved through screening affects disease outcomes and costs. This helps policymakers make informed decisions about the implementation of lung cancer screening programmes.

Transition probabilities are also key, as they dictate the likelihood of moving from one state to another in a defined period of time. These probabilities are derived from clinical data or literature, and reflect factors including, but not limited to:

- screening sensitivity
- screening specificity
- disease progression
- survival rates
- treatment success rates
- mortality rates
- wider factors, such as access to onward treatment and time to treatment.

The model typically progresses in discrete time steps, often represented by cycles (e.g. one cycle per month).[9] At each cycle, individuals can transition to different states based on the probabilities, and the model tracks these transitions over multiple cycles to simulate long-term outcomes.

Microsimulation model

Microsimulation models simulate individuals' life histories.* Each individual is modelled separately and can have unique characteristics, including different risk factors, comorbidities or treatment responses. In this way, a microsimulation model provides more detail than an aggregate model, such as the Markov model.

Microsimulation models allow for the modelling of heterogeneous populations. This is particularly important in lung cancer screening, where different subgroups (e.g. people who smoke, people who used to smoke, age groups, or people with comorbidities) may experience different risks, screening outcomes and disease progression.

Examples of microsimulation models being used for lung cancer screening include the Microsimulation Screening Analysis for Lung Cancer (MISCAN-Lung) model, the Lung Cancer Policy Model (LCPM) and the Microsimulation Lung Cancer (MILC) model.

Natural history model

A natural history model for cost-effectiveness analysis of lung cancer screening simulates the progression of lung cancer without any interventions, then compares this to the outcomes when screening is applied. The model tracks how the disease progresses naturally, often based on historical data, and helps estimate the costs and health outcomes associated with that progression. The model then evaluates the costs and effectiveness of a screening programme in detecting lung cancer earlier and improving patient outcomes.

Natural history models provide essential inputs (e.g. disease progression and health outcomes) for more complex models like Markov or discrete-event simulation models, but they are also flexible enough to be used independently in some analyses.[11]

Decision tree

Decision trees are graphical models used to represent the possible outcomes of healthcare interventions, and the subsequent health and economic consequences. They are used to estimate the expected costs and outcomes of a decision, and consider various probabilities (e.g. screening vs. no screening, or comparing multiple screening methods). A decision tree is made up of nodes:

- Decision node: the point at which decisions must be made, such as whether to conduct screening
- Terminal node: the final outcome or consequence, such as health outcomes or costs
- Chance node: the point at which several possible events can occur, such as whether an individual tests positive or negative for lung cancer after screening.

Model parameters

Outcomes can be different depending on the input parameters used, which may include:[7 12]

- screening population
- invitation and participation (uptake)
- screening interval
- incidental findings
- mortality reduction
- overdiagnosis
- infrastructure
- smoking cessation
- lead-time bias†
- length bias‡

The data used in a cost-effectiveness analysis have a significant impact on the results, so it is crucial to use accurate and context-specific information. In some cases, national data may not be available; where this is the case, data can be gathered through feasibility studies or estimated using information from comparable countries. To understand the reliability of the analysis, it is also important to examine how sensitive the results are to changes in key inputs – this can be done through **scenario and sensitivity analyses** (see page 4).

* The term 'life history' refers to significant events in an individual's life,[10] including health events (e.g. onset of a disease), demographic events (e.g. ageing), behavioural events (e.g. smoking cessation) and socioeconomic events (e.g. changes in income).

† Lead-time bias is the overestimation of survival in a screening study due to diagnosing earlier, without actually changing the time of death.[2]

‡ Length bias is when screening studies find slower-growing cancers but miss faster-growing ones. If this bias is not accounted for, the results may wrongly depict the screening as more effective than it actually is.[2]

Types of outcome measures

Outcome measures for cost-effectiveness analyses quantify the health benefits or effects of an intervention. They are essential for comparing the costs and outcomes associated with different interventions, and they inform decision-making on which interventions offer the best value for money. Outcome measures are tailored to the goals and nature of the intervention, and their selection depends on the disease, the intervention, and the perspective of the analysis. Examples of outcome measures include:

- quality-adjusted life years (QALYs)
- disability-adjusted life years (DALYs)
- incremental cost-effectiveness ratio (ICER)
- cost-benefit ratio
- net benefits
- life years saved
- cases avoided
- deaths prevented

Scenario and sensitivity analyses

Every cost-effectiveness analysis is based on a number of assumptions, some of which may not be accurate. Scenario and sensitivity analyses measure and evaluate this uncertainty.

Scenario analysis involves assessing how the results of a cost-effectiveness analysis change under different assumptions or hypothetical scenarios; multiple scenarios are evaluated based on variations in key assumptions, factors or conditions. They may include base-case scenarios, best-case scenarios, worst-case scenarios or alternative-intervention scenarios.[13]

Sensitivity analysis is used to assess how uncertainty in key model parameters affects the cost-effectiveness results.[13] It helps evaluate the robustness of the finding drawn from the cost-effectiveness analysis model, and helps determine which parameters are most influential in determining the cost-effectiveness of an intervention. If results are highly sensitive to a few key parameters, efforts can be focused on gathering more precise data for those variables to address the uncertainty.

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References

1. Wouterse B, van Baal P, Versteegh M, *et al.* 2023. The Value of Health in a Cost-Effectiveness Analysis: Theory Versus Practice. *Pharmacoeconomics* 41(6): 607-17
2. Turner HC, Archer RA, Downey LE, *et al.* 2021. An Introduction to the Main Types of Economic Evaluations Used for Informing Priority Setting and Resource Allocation in Healthcare: Key Features, Uses, and Limitations. *Front Public Health:* 10.3389/fpubh.2021.722927
3. U.S Department of Veterans Affairs. Budget Impact Analysis. [Updated 04/05/25]. Available from: https://www.herc.research.va.gov/include/page.asp?id=budget-impact-analysis [Accessed 28/02/25]
4. Office for Health Improvement and Disparities. Economic evaluation: health economic studies. [Updated 19/05/21]. Available from: https://www.gov.uk/guidance/economic-evaluation-health-economic-studies [Accessed 28/02/25]
5. Sittimart M, Rattanavipapong W, Mirelman AJ, *et al.* 2024. An overview of the perspectives used in health economic evaluations. *CERA:* 10.1186/s12962-024-00552-1
6. Chalkidou K, Culyer AJ, Nemzoff C. 2018. *Perspective in Economic Evaluations of Healthcare Interventions in Low- and Middle-Income Countries: One Size Does Not Fit All.* Washington: Center for Global Development
7. Peters JL, Snowsill TM, Griffin E, *et al.* 2022. Variation in Model-Based Economic Evaluations of Low-Dose Computed Tomography Screening for Lung Cancer: A Methodological Review. *Value in health* 25(4): 656-65
8. Goulart BH, Bensink ME, Mummy DG, *et al.* 2012. Lung cancer screening with low-dose computed tomography: costs, national expenditures, and cost-effectiveness. *J Natl Compr Canc Netw* 10(2): 267-75
9. Hofmarcher T. 2025. Personal communication by email: 06/04/25
10. Schultz FW, Boer R, de Koning HJ. 2012. Chapter 7: Description of MISCAN-lung, the Erasmus MC Lung Cancer microsimulation model for evaluating cancer control interventions. *Risk Anal* 32(Suppl 1): S85-98
11. Nargund RS, Ishizawa S, Eghbalizarch M, *et al.* 2025. Natural history models for lung Cancer: A scoping review. *Lung cancer:* 10.1016/j.lungcan.2025.108495
12. Morgan H, Baldwin DR. 2023. Important parameters for cost-effective implementation of lung cancer screening. *Brit J Radiol:* 10.1259/bjr.20220489
13. Briggs AH, Gray AM. 1999. Handling uncertainty in economic evaluations of healthcare interventions. *BMJ* 319(7210): 635-8

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