

Long-term evaluation of benefits, harms, and cost-effectiveness of the National Bowel Cancer Screening Program in Australia: a modelling study

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Summary

Background No assessment of the National Bowel Screening Program (NBCSP) in Australia, which considers all downstream benefits, costs, and harms, has been done. We aimed to use a comprehensive natural history model and the most recent information about cancer treatment costs to estimate long-term benefits, costs, and harms of the NBCSP (2 yearly immunochemical faecal occult blood testing screening at age 50–74 years) and evaluate the incremental effect of improved screening participation under different scenarios.

Methods In this modelling study, a microsimulation model, Policy1-Bowel, which simulates the development of colorectal cancer via both the conventional adenoma-carcinoma and serrated pathways was used to simulate the NBCSP in 2006–40, taking into account the gradual rollout of NBCSP in 2006–20. The base-case scenario assumed 40% screening participation (currently observed behaviour) and two alternative scenarios assuming 50% and 60% participation by 2020 were modelled. Aggregate year-by-year screening, diagnosis, treatment and surveillance-related costs, resource utilisation (number of screening tests and colonoscopies), and health outcomes (incident colorectal cancer cases and colorectal cancer deaths) were estimated, as was the cost-effectiveness of the NBCSP.

Findings With current levels of participation (40%), the NBCSP is expected to prevent 92 200 cancer cases and 59 000 deaths over the period 2015–40; an additional 24 300 and 37 300 cases and 16 800 and 24 800 deaths would be prevented if participation was increased to 50% and 60%, respectively. In 2020, an estimated 101 000 programme-related colonoscopies will be done, associated with about 270 adverse events; an additional 32 500 and 49 800 colonoscopies and 88 and 134 adverse events would occur if participation was increased to 50% and 60%, respectively. The overall number needed to screen (NNS) is 647–788 per death prevented, with 52–59 colonoscopies per death prevented. The programme is cost-effective due to the cancer treatment costs averted (cost-effectiveness ratio compared with no screening at current participation, AU\$3014 [95% uncertainty interval 1807–5583] per life-year saved) in the cost-effectiveness analysis. In the budget impact analysis, reduced annual expenditure on colorectal cancer control is expected by 2030, with expenditure reduced by a cumulative AU\$1.7 billion, AU\$2.0 billion, and AU\$2.1 billion (2015 prices) between 2030 and 2040, at participation rates of 40%, 50%, and 60%, respectively.

Interpretation The NBCSP has potential to save 83 800 lives over the period 2015–40 if coverage rates can be increased to 60%. By contrast, the associated harms, although an important consideration, are at a smaller magnitude at the population level. The programme is highly cost-effective and within a decade of full roll-out, there will be reduced annual health systems expenditure on colorectal cancer control due to the impact of screening.

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Introduction

Colorectal cancer is the third most common cancer in Australia and the second most common cause of cancer death, with 14 962 new cases of bowel cancer diagnosed and 4149 bowel cancer deaths reported in 2013.¹ Most colorectal cancer cases (>90%) are diagnosed in individuals aged 50 years or older and the disease is more common in men than in women.¹ Due to the high burden of disease and the availability of new treatments for advanced cancer, the costs related to treatment are considerable, and have increased substantially over the

past decade to an estimated AU\$1 billion annually in 2013.² Additionally, there are major costs associated with colonoscopy, sometimes used for ad-hoc screening, with an estimated 700 000 colonoscopies (for all purposes) done in 2012 in Australia.³

Screening with the faecal occult blood test (FOBT) has been shown to be effective in reducing bowel cancer incidence and mortality in long-term cohort follow up and in trials.⁴ In Australia, the National Bowel Cancer Screening Program (NBCSP) was introduced in late 2006, offering free immunochemical faecal occult blood

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Research in context

Evidence before this study

Screening with the faecal occult blood test has been found to be effective in reducing bowel cancer incidence and mortality in long-term cohort follow-up and in trials. In Australia, the National Bowel Cancer Screening Program (NBCSP) was introduced in late 2006 and will be fully rolled out by 2020, at which stage it will offer biennial screening with free immunochemical faecal occult blood testing (iFOBT) to all people aged 50–74 years. The overall participation rate was 37% in 2013–14. Colorectal cancer treatment costs in Australia have increased rapidly in the past two decades. We searched PubMed and MEDLINE in March to April, 2016, to identify economic evaluations of biennial iFOBT screening in individuals aged 50–74 years in Australia. The literature review identified three modelling or health economics studies. However, no assessment that takes into account the effect of screening and surveillance on all downstream health and cost outcomes and the rapid increase in colorectal cancer treatment costs has been done.

Added value of this study

We did a comprehensive evaluation of the long-term benefits, costs, and harms of the NBCSP using a well calibrated and validated model, *Policy1-Bowel*. The model took into account both the conventional adenoma-carcinoma pathway and the serrated pathway in the natural history of colorectal cancer development, the phased implementation of NBCSP in the period 2006–20, the detailed management pathways for

screening and colonoscopy surveillance, and the observed screening behaviour. The model also incorporated all the downstream benefits, costs, and harms of the NBCSP and the most recent information about cancer treatment costs, which have been rapidly increasing in Australia, in the cost-effectiveness evaluation. The study provided detailed predictions of the number of colorectal cancer cases, colorectal cancer deaths, the overall NBCSP programme cost, and resource use (including number of iFOBT test kits sent and returned to the programme, programme-related colonoscopies, and adverse events) that would occur in the period between 2006 and 2040.

Implication of all the available evidence

Our study findings suggest that the NBCSP in Australia will be very effective in reducing colorectal cancer mortality, and its effectiveness would be further increased with improved participation. The NBCSP was found to be highly cost-effective in the cost-effectiveness analysis, which involves discounting costs and effects over the lifetime of a single cohort. Findings from the (undiscounted) budget impact analysis for each year showed that the total annual cost to the health system to provide iFOBT screening, colonoscopy follow-up and surveillance, and colorectal cancer treatment would become less than the total cost without screening within a decade of full rollout of the programme in 2020, due mainly to avoidance of treatment costs for colorectal cancer.

testing (iFOBT) for Australians turning 55 years and 65 years in that year.⁵ The programme has been expanding since then, via the addition of new age cohorts. The programme will be fully rolled out by 2020, at which stage it will offer biennial screening to all people aged 50–74 years. However, in the period between 2006 and 2019, some age cohorts will have been screened at a longer interval (for example, the birth cohort who received the first screening invitation at the age of 55 years in 2006 were eligible for the second screening invitation in 2016).⁵ In 2013–14, about 2.3 million iFOBT test kits were sent by the NBCSP to eligible Australians (individuals aged 50 years, 55 years, 60 years, and 65 years) and 836 457 kits were completed and returned to the programme (yielding a participation rate of about 37.3%).⁵ The reported overall positivity rate of the completed iFOBT tests was 7.0%.⁵

Three modelling or economic studies have been done to evaluate biennial iFOBT screening for people aged 50–74 years in Australia, but none of these have taken into account the effect of screening and surveillance on all downstream health and cost outcomes; and no analysis, to the best of our knowledge, to date has accounted for the rapid increase in colorectal cancer treatment costs in the past two decades.^{2,6–8} A summary of the findings of these three studies is shown in the appendix.

The aims of this study were therefore to derive an accurate and updated estimate of the benefits, harms, resource use, annual expenditure, and cost-effectiveness of the fully implemented NBCSP in Australia over the period between 2015 and 2040, taking into account the effect of gradual rollout of the screening programme before 2020, the most current data for cancer treatment costs, and the effect of downstream management, including colonoscopy surveillance, on both the effects and costs of the programme; and to assess the effect of improved screening participation on these outcomes.

Methods

Model calibration and validation

We used the *Policy1-Bowel* microsimulation platform, which was developed by adapting and recalibrating an existing colorectal cancer natural history model, the Adenoma and Serrated Pathway to Colorectal CAncer model (ASCCA),⁹ to natural history data and the Australian setting. The *Policy1-Bowel* model was constructed using Microsoft Visual Studio 2013 C++.

The model simulates 10 million men and 10 million women per single year age cohort, and incorporates sex-specific life table data. The simulation begins from age 20 years and continues on an annual time-step until the individual dies or becomes 90 years old, whichever occurs

See Online for appendix

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