Colonoscopy requirements of population screening for colorectal cancer in New Zealand

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Abstract

Aim To estimate the colonoscopy burden of introducing population screening for colorectal cancer in New Zealand.

Methods Screening for colorectal cancer using biennial immunochemical faecal occult blood tests offered to people aged 50–74 years of age was modelled using population estimates from Statistics New Zealand for 2011–2031. Modelling to determine colonoscopy requirements was based on participation and test positivity rates from published results of screening programmes. Estimates of the number of procedures required for ongoing adenoma surveillance were calculated using screening literature results of adenoma yield, and New Zealand Guidelines for Adenoma Surveillance. Sensitivity analysis was undertaken on key parameters.

Results For a test positivity of 6.4%, biennial screening using immunochemical faecal occult blood testing with a 60% participation rate, would require 18,000 colonoscopies nationally, increasing to 28,000 by 2031. The majority of procedures are direct referrals from a positive FOBT, with surveillance colonoscopy numbers building over time.

Conclusion Colonoscopy requirements for immunochemical faecal occult blood based population screening for colorectal cancer are high. Significant expansion of services is required and careful management of surveillance procedures to ensure timely delivery of initial colonoscopies whilst maintaining symptomatic services. A model re-run informed by data from the screening pilot will allow improved estimates for the New Zealand setting.

Colorectal cancer is the second most common cause of cancer registration (2,801 registrations in 2008, accounting for 14% of all cancer registrations) and the second most common cause of cancer death (1280 deaths in 2008, accounting for 15% of all deaths from cancer) in New Zealand. Age-standardised colorectal cancer incidence rates are lower for Māori than for non-Māori, and for females than for males.[1]

The risk of colorectal cancer increases with age, and 90% of all cases diagnosed are in people aged 50 years or over.[1] Although colorectal cancer (CRC) incidence overall is forecast to decline in New Zealand, the absolute number of people with CRC is expected to increase, because the effects of growth and ageing of the population will more than offset the decline in incidence.[2]

CRC mortality rates overall have also been declining, and this decline is forecast to continue[2] but Māori CRC mortality rates have increased between 1980 and 1999[3] so that Māori and non-Māori rates are comparable currently. If these trends continue,

CRC mortality rates among Māori will exceed non-Māori rates, with disparities increasing over time.[4]

CRC Mortality is higher in New Zealand than Australia and most other countries.[5,6] It is suggested that this is partly due to the higher incidence of CRC in New Zealand but that it may also reflect poorer survival after diagnosis in NZ than Australia.[5]

Most colorectal cancers begin as adenomatous polyps, with progression to cancer taking at least 5–10 years. This means that detection at an early stage is possible. Treatment at an early stage is associated with a better prognosis than treatment at a later stage, but this is dependent on health services being able to offer timely and appropriate treatment.[7-9]

Screening for CRC involves testing asymptomatic people to identify those likely to have CRC. The most commonly used screening test is the faecal occult blood test (FOBT), which requires people to put stool samples on a card and send it to a laboratory to be tested for the presence of blood.

People with positive tests are offered colonoscopy to see if they have CRC. Screening with a particular type of FOBT, guaiac FOBT, has been shown in randomised controlled trials (RCTs) to reduce CRC mortality by about 15%.[10,11]

In 1997 the New Zealand National Health Committee convened a working party to consider population screening for CRC in New Zealand. This working party did not recommend population screening because of "the modest potential benefit, the considerable commitment of health sector resources, and the small but real potential for harm".[12,13]

In 2005 the National Screening Unit of the Ministry of Health convened an advisory group to revisit the issue of CRC screening, since it had been several years since the previous report. There were also new results from pilot programmes in the United Kingdom and Australia, and papers reporting longer follow up from the randomised controlled trials of CRC screening.

The advisory group recommended that a feasibility study of CRC screening using immunochemical faecal occult blood tests (FOBTi) be considered and planning initiated.[14]

The FOBTi test is not definitive and those with a positive test result need to be referred for colonoscopy for a confirmatory diagnosis. There is an ethical obligation to deliver this initial colonoscopy in a timely manner.

The advisory group regarded a feasibility study as an essential pre-requisite to any decision about screening in New Zealand in part because existing colonoscopy capacity was insufficient to consistently deliver, across the country, timely diagnostic colonoscopy for those with symptoms, or timely surveillance procedures for those at increased risk of CRC. This was in the absence of the additional demand that would be generated by a screening programme. Concern about colonoscopy capacity has continued to be raised.[15,16]

A pilot bowel screening programme was launched in the Waitemata District Health Board region, in October 2011. The pilot programme offers two-yearly FOBTi to eligible people aged 50–74 years, and will run for 4 years. This paper focuses on the

requirements for colonoscopy, should a national screening programme be introduced, with FOBTi as the screening test. It includes both the initial 'referral' colonoscopy following a positive FOBTi test, and surveillance colonoscopy arising from adenomas found at the initial colonoscopy.

Methods

Study design—Estimates of the New Zealand Population, base 2006, were obtained for the years 2011 to 2031. [17] Series 5 population projections, based on medium fertility and life expectancy, was used in the modelling. The estimated population aged 50–74 was 1.118 million in 2011 and 1.435 million in 2031.

FOBTi-based biennial screening of those aged 50–74 years, excluding those assumed to have already been diagnosed with colorectal cancer, was modelled following a Markov process. This involves patients moving from one 'stage' (e.g. being invited to screen) to another 'stage' (e.g. participating in screening) according to various probabilities. For example it was assumed that 60% of people would 'move' from being invited to being screened.

The stages included: the invitation to screen, the initial screen, referral to colonoscopy, uptake of colonoscopy, outcome of colonoscopy, adenoma surveillance and invitation to rescreen with FOBTi after 2 years, or after 5 years for those who had had a colonoscopy but no cancer or adenoma had been found (see Figure 1). This process was started in 2011 and stopped after 2031.

Figure 1. Faecal occult blood tests (FOBT) screening diagram
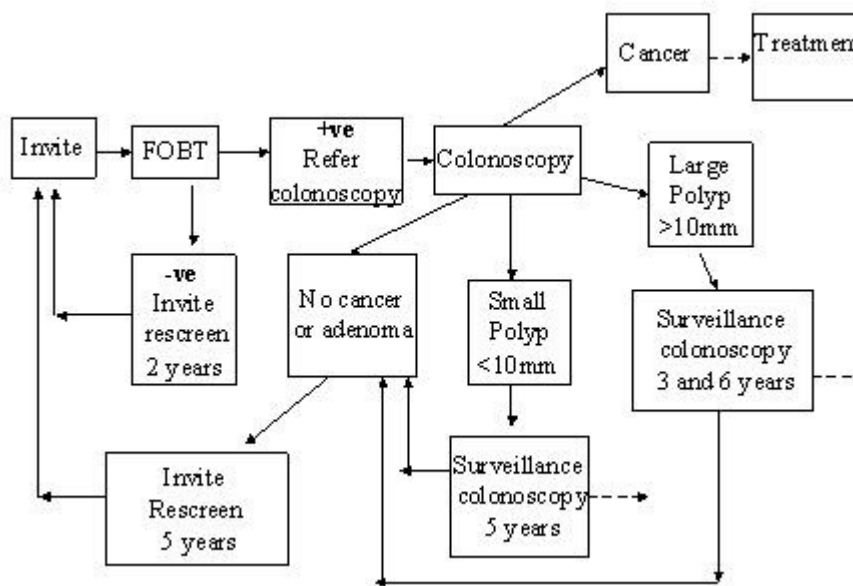
The model assumed that the initial screening would be spread over the first 2 years of the programme. Thus half the population aged 50-74 were eligible for screening in year 1; the remainder became eligible in year 2 except for those who had 'aged out' (became 75) or had died. Those who had 'aged into' the eligible age range (turned 50) in year 2 also became eligible for screening. For subsequent years the model allowed for 'aging in' and 'aging out'.

Surveillance colonoscopy of large adenomas (>10mm) was at 3 and 6 years, and was at 5 years for small adenomas. Surveillance beyond this was not modelled. The 2004 NZ Guidelines on which these surveillance parameters were initially based, recommended the first surveillance colonoscopy be

performed at 3 years for those with adenomas size >10 mm and those with greater than three adenomas.

The next surveillance procedure was recommended at 3–5 years if the colonoscopy was negative.[18] It was recognised that in practice a proportion of patients with large adenomas would have the second surveillance procedure at 5 years rather than 3 years, but on the other hand others following removal of a large adenoma with advanced histology, would have surveillance colonoscopy performed at one and 3 years, as had been recommended in the recently released NZ Guidelines.

To model surveillance procedures at 3 and 6 years following detection of a large adenoma, and to not model for surveillance beyond 6 years (which would certainly be required for a significant proportion) was considered to best reflect the range of surveillance scenarios that could result from the detection of large adenomas at the initial colonoscopy. Those undergoing surveillance were returned to FOBTi screening 5 years after their last normal colonoscopy.

The numbers of colonoscopies required each year, in total and separately for the initial referral and for adenoma surveillance, were calculated.

Base case scenario—For the base case, FOBTi test positivity was assumed to be 6.4% for the initial screen based on the Calvados, France FOBTi trial,[19] which screened people aged 50–74. Positivity for re-screening was not available and was estimated at 4.8% by assuming the same proportion of initial screen positivity (75%), as occurred in the Italian (Florence) FOBTi trial.[20] [The positivities in that trial for first and repeat screens were 4.4% and 3.3%.]

Uptake of FOBTi screening was assumed to be 60% based on the Nottingham RCT for guiac based FOBT[10] and uptake of referral colonoscopy was taken at 85%,[19] and was assumed to be 100% for surveillance. Yield of large adenomas (over 10mm) at colonoscopy was assumed to be 24%, and 20% for small adenomas.[19]

Alternative scenarios—The model was also run with 4% and 8% FOBTi positivity rates, and 70% FOBTi screening participation rate. A further model run was undertaken for the base case scenario, but with 90% participation in surveillance colonoscopy.

Results

For a FOBTi positivity rate of 6.4%, in the first year of a programme (2011), a total of 18000 colonoscopies are required, building up to 27000 by year 7, and reaching 28000 after 20 years (year 2031) (see Figure 2).

As expected, there will be a high need for colonoscopy in the first 2 years, for the prevalence round, following the first screen (18,000 in year 1 and over 19,000 in year 2).

**Figure 2. Total colonoscopies for biennial FOBTi screening 2011-2031**
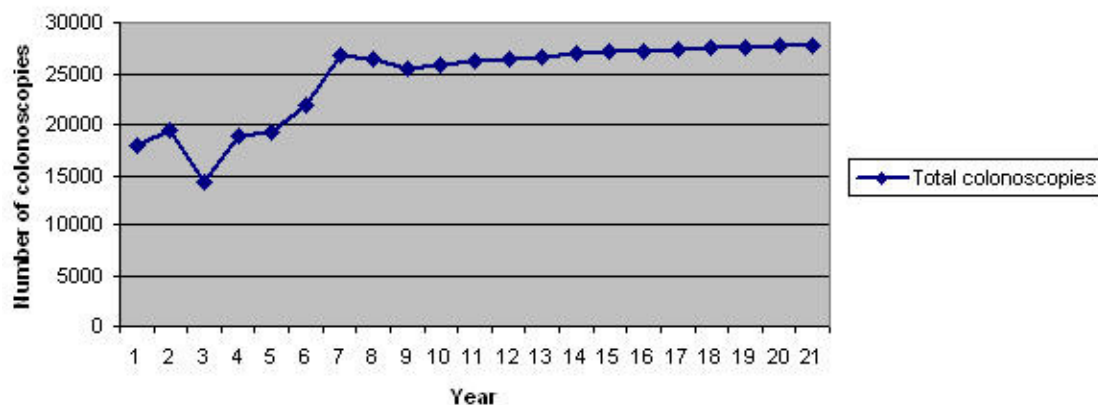
Figure 3. FOBTi screening: referral and surveillance colonoscopy 2011-2031
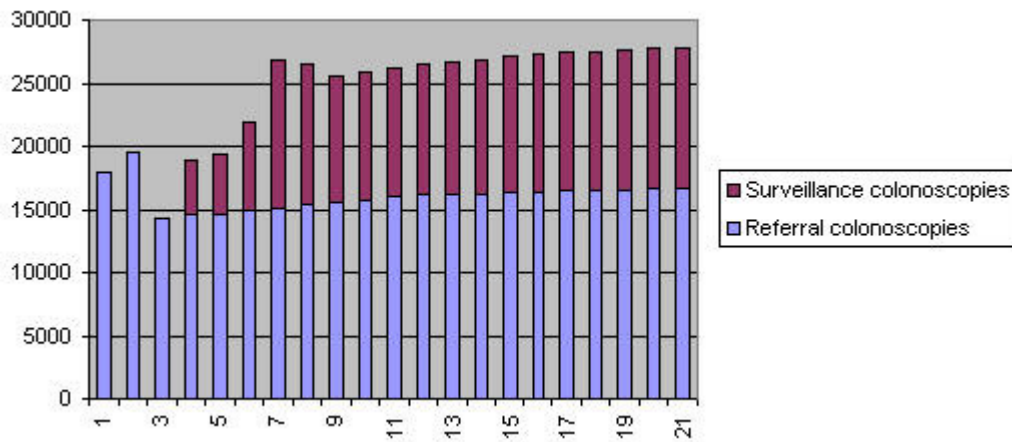
Total colonoscopies are made up of 'referral colonoscopies' (the first colonoscopy following a positive FOBTi) and surveillance colonoscopies to follow up adenomas found (see Figure 3). Once the prevalence round has passed, 'referral' colonoscopies, drop to 14000 and then show steady growth tracking the increase in the population, reaching 17000 after 20 years (see Figure 4).

**Figure 4. FOBTi screening: Build up of referral and surveillance colonoscopy 2011-2031**
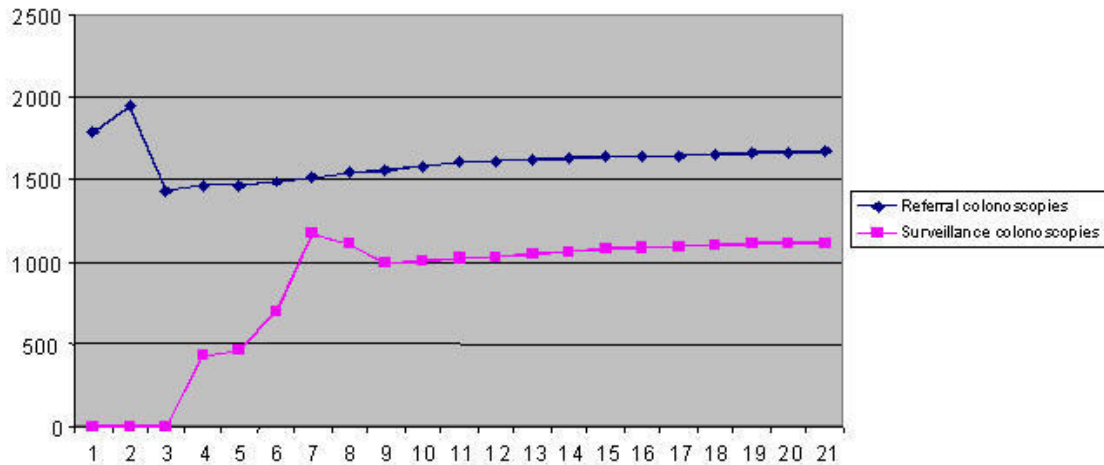
There were four outcomes of the referral colonoscopy: firstly those people found to have cancer, who were not modelled further; secondly and thirdly those with large or small adenomas, who were followed up with surveillance colonoscopy; fourthly those who had neither adenomas nor cancer, who were returned to be re-screened after 5

years. Just over half of the referral colonoscopies (i.e. 9000) would find neither adenomas nor cancer.

Adenomas were found in approximately 7000 people each year; 55% would have large adenomas and 45% small adenomas. Those with adenomas were referred for surveillance colonoscopy. Surveillance starts at year 4 of the programme requiring 4000 colonoscopies, and builds up to over 11,000 colonoscopies each year, by year 7 (Figure 4); 71% of these are for surveillance of large adenomas, with the remainder for small adenomas (see Figure 5).

Figure 5. FOBTi screening: colonoscopy for surveillance of large and small adenomas
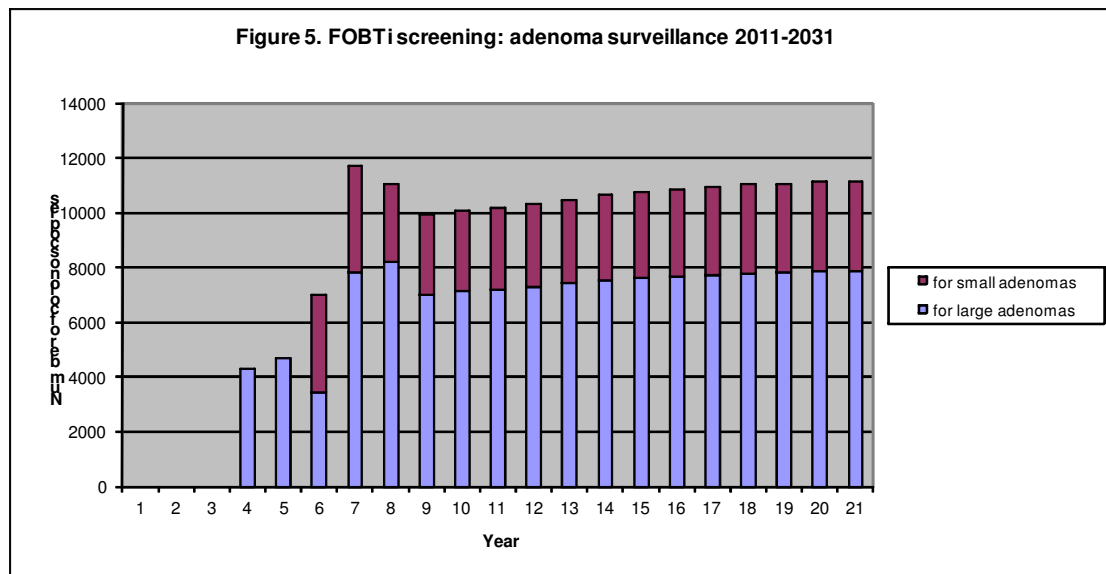
Sensitivity analysis—Table 1 shows results for different values of the FOBTi positivity rate, and screening participation. The number of colonoscopies is shown for year 1 of the programme and for year 7 (corresponding to years 2011 to 2017). This spans the period corresponding to the sharp rise in demand for colonoscopy services, which must be planned for. After year 7, yearly demand increases, but at a much lower rate.

The most important parameter is the positivity of the FOBTi test, since this determines the volume of referral colonoscopies. Reducing positivity for the first screen to 4%, and 3% for subsequent screens, resulted in 11,000 colonoscopies in year 1 increasing to 17,000 by year 7. Increasing the positivity to 8% and 6% respectively for first and subsequent screens, increased these values to 22,000 in year 1, and 33,000 in year 7.

The positivity rate determines both the number of cancers and adenomas found. Higher positivity brings greater benefit, but increases the number of colonoscopies required.

If participation in the FOBTi screening test increased from 60% to 70%, and assuming other parameters were as for the base case scenario (including FOBTi test positivity of 6.4%) the number of colonoscopies required in year 7 would be 31,000.

All values in Table 1 assume 85% compliance with the referral colonoscopy, following a positive FOBTi, and 100% compliance with surveillance colonoscopy. If participation in surveillance colonoscopy is reduced to 90%, and assuming all other parameters are as for the base case scenario, then total colonoscopies in year 7 reduce to 25,600. This includes 10,500 for surveillance.

Table 1. Sensitivity analysis - Colonoscopy requirements (year 1 and year 7)

Variables	4% positivity		6.4% positivity		8% positivity	
60% participation	**year 1**	**year 7**	**year 1**	**year 7**	**year 1**	**year 7**
Referral colonoscopy	11,000	10,000	18,000	15,000	22,000	19,000
Surveillance – large adenomas	0	5000	0	8000	0	10,000
Surveillance – small adenomas	0	2000	0	4000	0	5000
Total	**11,000**	**17,000**	**18,000**	**27,000**	**22,000**	**33,000**
70% participation	**year 1**	**year 7**	**year 1**	**year 7**	**year 1**	**year 7**
Referral colonoscopy	13,000	11,000	21,000	18,000	26,000	22,000
Surveillance – large adenomas	0	6000	0	9000	0	11,000
Surveillance – small adenomas	0	3000	0	5000	0	6000
Total	**13,000**	**20,000**	**21,000**	**31,000**	**26,000**	**39,000**

Discussion

The benefit of a national screening programme for colorectal cancer are achieved by detecting early stage CRC at colonoscopy performed as follow-up to a positive FOBTi. However, at the initial referral colonoscopy over 40% of people will be found to have adenomas, which, according to current NZ guidelines, require ongoing colonoscopic surveillance. There is an ethical obligation for the initial confirmatory procedure and subsequent surveillance procedures to be delivered in a timely manner.

The results show that the requirement for colonoscopy following the introduction of a national screening programme is substantial. In the first few years of a programme, most of the requirement for colonoscopy is for the initial referral after a positive FOBTi, but by year 7, surveillance colonoscopies will have built up and are estimated to account for 44% of the total. Approximately 70% of this adenoma surveillance would be for large adenomas, and 30% for small adenomas.

Colonoscopy capacity needs to expand to meet this demand. A survey[21] commissioned for the 2006 Advisory group found that capacity had increased since the 1998 working group report, but was still insufficient to consistently deliver, across the country, timely diagnostic colonoscopy for those with symptoms or timely surveillance procedures for those at increased risk of CRC. This was in the absence of the additional demand that would be generated by a screening programme. The estimates in this paper provide information on requirements under various scenarios, to support capacity planning.

There are a number of limitations to our study. The rates of adenoma yield were assumed constant over the screening age band (50–74 years). Yet adenoma prevalence increases with age (leading to a higher yield for older people screened.[22,23] On the other hand, participation, which may decline with age, was also assumed constant. Thus there may be some compensating effect of these two assumptions. Moreover the parameters used in the modelling were themselves averages across age bands, and therefore appropriate to generate total colonoscopies for the age band screened.

An important issue is the appropriateness of using parameters based on overseas populations, when modelling the New Zealand population. This applies to participation in screening, including for gender and ethnicity subgroups. At present there is no information on the uptake of FOBTi screening in New Zealand. It is anticipated that 60% of eligible people will participate in the Waitemata pilot bowel screening programme. This pilot programme started in October 2011.

Adenoma yield in New Zealand may also differ from that of overseas populations. A study of 2,842 people undergoing colonoscopy in Auckland, excluding those with indications associated with high or low adenoma prevalence[24] found that the prevalence of histologically proven adenomas among 40–59 year olds was 8.7% for Maori and 16.7% for non-Maori.

Surveillance of large adenomas after 6 years was not included in the modelling. To model surveillance procedures at three and 6 years following detection of a large adenoma, and to not model for surveillance beyond 6 years, was considered to best reflect the range of surveillance scenarios (as described in the methods section) that could result from the detection of large adenomas at the initial colonoscopy. However, discovery of further adenomas (at 3 or 6 years) would initiate a further sequence of surveillance for a proportion of individuals and thus the results presented here could potentially be conservative.

But this underestimation may compensate for the overestimation due to the assumption of 100% compliance in surveillance assumed for the base case scenario, when in fact compliance with surveillance colonoscopy may decline with age as a consequence of comorbid health conditions. Reducing participation in surveillance colonoscopy to 90% provides a further estimate of the colonoscopy burden, with surveillance procedures now 41% of the total.

This modelling has used parameter values from overseas studies. The actual number of colonoscopies required for a national screening programme in New Zealand, will depend on the participation for the initial screen and then compliance with the first colonoscopy and subsequent surveillance colonoscopy. The sensitivity analysis provides some estimates of possible colonoscopy volumes with various parameter values.

The pilot bowel screening programme in Waitemata DHB region should provide New Zealand specific information on many of the parameters assumed for this modelling, and the model could be run again to generate new estimates.

The number of colonoscopies also depends on adenoma surveillance protocols and practice. The modelling was consistent with existent NZ guidelines on adenoma surveillance but updated guidelines have recently been released advocating an additional surveillance procedure at a year for individuals with high risk adenomas.[18]

This would further add to the surveillance burden. Current practice may also vary around these guidelines with a consequent effect on total surveillance colonoscopies.

Lack of adequate colonoscopy capacity to meet both the (new) demand from a screening programme and the (existing) demand for people with symptoms or at high risk runs the risk of compromising both demand streams. Concern about meeting demand for colonoscopy has been expressed in other countries, in Ireland which is planning the introduction of a screening programme, [25] and in England, which established a pilot study in 2000 and began national roll-out in 2006.

Research on the second round of screening in the English pilot study reported, in relation to staff in endoscopy units, that "managing screening-generated surveillance colonoscopies in a timely manner while meeting diagnostic work (both Pilot and non-Pilot) was challenging". [26]

Planning for a national screening programme in New Zealand needs to take account of capacity requirements for surveillance colonoscopy, as well as for the initial referral colonoscopy.

Surveillance colonoscopy need to be carefully managed and guidelines for surveillance of low risk adenomas scrutinised to ensure that the burden of colonoscopic surveillance following detection of adenomas does not lead to unacceptable waiting times for the initial referral colonoscopy or for procedures required for people with symptoms.

Conclusion

Realising the benefits of a national screening programme for colorectal cancer, using the immunochemical faecal occult blood based screening test (FOBTi) requires provision of timely colonoscopy, for a confirmatory diagnosis of CRC.

Total colonoscopy requirements of a screening programme, including for adenoma surveillance are high and expansion of colonoscopy services is required to meet this demand without compromising services for people with symptoms. The demand depends on the positivity setting of the test. Higher positivity will give a higher cancer yield but will require more referral colonoscopies to detect CRC and for subsequent adenoma surveillance.

Surveillance following adenoma detection accounts for a significant proportion of screening colonoscopies and needs to be carefully managed so that it does not compromise the delivery of timely diagnostic colonoscopy for people with symptoms or timely initial colonoscopy following a positive FOBTi as part of a population CRC screening programme.

Colonoscopy volumes also depend on screening participation rates and adenoma yield. When data becomes available from the pilot study, the model can be rerun to give estimates more representative of the New Zealand setting and population.

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