Modelling the full spectrum of colon cancer screening in Australia

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the CRC-Spin Model

- a microsimulation model, it models down to the individual adenomas;
- includes a:
  - baseline risk of an adenoma;
  - an age related risk (shown in top figure for high, medium and low risk males and females);
  - adenoma growth curves (shown in bottom figure);
  - transition to cancer (shown by color in bottom figure).
- 24 parameters, validated against a number of data sets;
- see Rutter and Savarino (2010).
Overview of Screening Modelling Project

**AIM**
1) model the full set of screening modalities
2) introduce a plausible model of “propensity to screen”
3) estimate the number screened at different ages
4) evaluate the potential to increase the number screened with the current modalities
5) estimate the impact of a new novel screen

**Current practice**
model a single intervention
screening compliance modelled model as independent events
not well characterized
paths to bowel screening

There are four screening modalities available in Australia:

- the National Bowel Cancer Screening Program (NBCSP), 500,687 screens\(^1\);
- self-motivated screening (BSA and other programs) program, 100,000 screens per year (2012 data);
- screening colonoscopies, 160,000 per year;
- The General Practitioner initiated screening, 244,138 tests (2015 data);

and one non-screening path:

- symptomatic detection.

\(^1\)2013-2014 data; however (AIHW, 2016) reports 836,500.
## Rollout of NBCSP

<table>
<thead>
<tr>
<th>Phase</th>
<th>Start date</th>
<th>End date</th>
<th>Target ages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7 August 2006</td>
<td>30 June 2008</td>
<td>55 and 65</td>
</tr>
<tr>
<td>2</td>
<td>1 July 2008</td>
<td>30 June 2011&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50, 55 and 65</td>
</tr>
<tr>
<td>2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1 July 2011</td>
<td>30 June 2013</td>
<td>50, 55 and 65</td>
</tr>
<tr>
<td>3</td>
<td>1 July 2013</td>
<td>1 January 2015</td>
<td>50, 55, 60 and 65</td>
</tr>
<tr>
<td>4</td>
<td>1 January 2015</td>
<td>1 January 2016</td>
<td>50, 55, 60, 65, 70 and 74</td>
</tr>
<tr>
<td>4</td>
<td>1 January 2016</td>
<td>1 January 2017</td>
<td>50, 55, 60, 64, 65, 70, 72 and 74</td>
</tr>
<tr>
<td>4</td>
<td>1 January 2017</td>
<td>1 January 2018</td>
<td>50, 54, 55, 58, 60, 64, 68, 70, 72 and 74</td>
</tr>
<tr>
<td>4</td>
<td>1 January 2018</td>
<td>1 January 2019</td>
<td>50, 54, 58, 60, 62, 64, 66, 68, 70, 72 and 74</td>
</tr>
<tr>
<td>4</td>
<td>1 January 2019</td>
<td>ongoing</td>
<td>50, 52, 54, 56, 58, 60, 62, 64, 66, 68, 70, 72 and 74</td>
</tr>
</tbody>
</table>

NBCSP phases and target populations. The eligible population for all Phases incorporates those turning the target ages from 1 January of that year, onwards. The full rollout of the scheme has been accelerated, so that it will be offered biennially by 2019.

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<sup>a</sup>Eligible birth-dates, and thus invitations, ended on 31 December 2010

<sup>b</sup>Ongoing NBCSP funding commenced.
Compliance for NBCSP

- Percentage participating in the NBCSCP by age and time period
- downwards drift in compliance rates until 2013-2014
- 60 year old screening group added in 2013-2014, and increase in compliance in all age groups
- While there is a 2016 monitoring report (AIHW, 2016), it gives data for 2013-2014 as the latest
Self Motivated Screening

- The age distribution of the people using the home screening kit;
- the red bars indicate years in which people would have been eligible for NBCSP kits;
- we use this data to create an age-specific compliance rate.
GP initiated stool test

- not all cancer screening, note early ages;
- The positivity rate will be higher for this group as it includes those with symptoms;
- Due to the fact that the data is only available in 10-year segments we can not see any interaction with the NBCSP program;
- new deidentified linked data set (Department of Health, 2016) could be used to understand peoples behaviour over time.
colonoscopy numbers in the Sydney area.

We have estimated that 160000 screening colonoscopies are performed in Australia every year. 

On the basis of
- interview surveys (Zajac et al., 2013; Courtney et al., 2012)
- correlation with SES (Dunne and Bauer, 2016; Atlas of Healthcare Variation, 2016)
- disparities in rates between areas close together (with no evidence of differences in disease burden) (Dunne and Bauer, 2016)

We argue that a significant number of screening colonoscopies are performed in Australia every year. We note that Atlas of Healthcare Variation (2016) comes to the same conclusion but does not estimate a figure.
Colonoscopies

- This is a controversial suggestion as:
  - waiting times for colonoscopies at many public hospitals has blown out to unacceptable times;
  - it indicates a poor allocation of resources:
    * people who have had a positive FIT test are waiting for a colonoscopy;
    * it has the potential to get worse. As we screen more people, we will get more positive tests and so the required number of colonoscopies will rise.

- Quintero et al. (2012) has shown that:
  - using colonoscopy as the screen we find one cancer in 200 procedures;
  - using FIT (and then colonoscopy for the positives) we find one in 20 colonoscopies;

- not all agree that FIT screening is the way to go (some GP, patients, care providers advocate colonoscopies).
Screening behaviour – propensity

- compliance is the great driver;
- we now have more data on what determines propensity to screen. The literature suggests it linked to
  - age;
  - sex;
  - ethnicity and class;
  as well as the approach (an unexpected kit in the mail as opposed to a GPs recommendation);
- usually modelled as independent events
- Ladabaum and Mannalithara (2016) divide the population into 5 segments with different probabilities of screening (0.1, 0.3, 0.5, 0.7, 0.9).
Screening behaviour – propensity

- Propensity for each person is modelled by selecting a value $u$ from a $\beta(a, b)$ distribution (shown).
- $F^{-1}(u) = m$ where $f$ is a log Normal distribution with mean equal to the observed age specific compliance rate.
- $m$ is then the probability of screening.

- We introduce a “propensity to screen” (see figure) where every individual has a randomly sampled propensity.
- We see that many people have a very low propensity to screen while others are very inclined to do so.
- We include propensity in the model but also match the observed screening rates and the observed re-screening rates.
A Combined Model – the current situation

- self-motivated screening (SMS)
  - age specific compliance rate
  - propensity to screen model
- NBCSP
  - observed compliance rate at ages 50, 55, 60, 65
  - NBCSP propensity model
- colonoscopy
  - SMS age specific compliance rate
  - SMS propensity to screen
- GP based
  - age specific compliance rate (10 year intervals)
  - no propensity model
Combined Model

The figure shows the current situation with all screening modalities.

- NBCSP
- screening colonoscopies
- SMS
- GP motivated

The dotted line is the proportion of people in an unscreened population with a large undetected adenoma. The yellow line is the same proportion with the combined screening model.

58% of people covered at age 65 (a NBCSP covered year).
Adding a new blood test – the downstaging effect

<table>
<thead>
<tr>
<th>stage</th>
<th>current screening</th>
<th>blood test</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>symptomatic</td>
<td>screening</td>
<td></td>
</tr>
<tr>
<td></td>
<td>760</td>
<td>764</td>
<td>90</td>
</tr>
<tr>
<td>B</td>
<td>930</td>
<td>922</td>
<td>28</td>
</tr>
<tr>
<td>C</td>
<td>2172</td>
<td>2122</td>
<td>-52</td>
</tr>
<tr>
<td>D</td>
<td>790</td>
<td>820</td>
<td>-40</td>
</tr>
<tr>
<td>death</td>
<td>260</td>
<td>238</td>
<td>-22</td>
</tr>
<tr>
<td>total</td>
<td>6278</td>
<td>6362</td>
<td></td>
</tr>
</tbody>
</table>

- change in cancer detection from the current modality to one including a blood test. The “change” indicates the changes going from the current screening situation to one using a new blood test.

- blood test offered by GP to people over 65 who have not had a FIT in the previous 2 years or a colonoscopy in the previous 10

- the table illustrates the “down-staging” effect. All colon cancers are detected in the model unless the patient dies of something before detection. If we detect more stage A then we will see less stage D cancer.
Conclusions

- the expansion of the NBCSP may be at the expense of other FIT screening modalities;
- we may be in the situation where the “propensity to screen” limits the uptake of FIT tests to a subset of the population;
- a significant proportion of the population are up to date at certain ages (partly due to screening colonoscopies);
- new data (such as the deidentified linked data set (Department of Health, 2016)) could be used to understand peoples behaviour over time;
- The study identifies a non-compliant segment of the population who could be a target for a “rescue” intervention with a blood test.
References


Department of Health (2016). Linkable de-identified 10% sample of Medicare Benefits Schedule (MBS) and Pharmaceutical Benefits Schedule (PBS). [Online; accessed Thursday, September 29, 2016].


Adding a blood test – comparing different scenarios

<table>
<thead>
<tr>
<th>stage</th>
<th>current screening</th>
<th>blood test (65)</th>
<th>blood test (55,65,75)</th>
<th>blood test (50,55,60,65,70,75)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>symptomatic</td>
<td>screening</td>
<td>symptomatic</td>
<td>screening</td>
</tr>
<tr>
<td>A</td>
<td>760</td>
<td>942</td>
<td>706</td>
<td>1046</td>
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<tr>
<td>B</td>
<td>930</td>
<td>220</td>
<td>928</td>
<td>254</td>
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<tr>
<td>C</td>
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<td>196</td>
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<td>178</td>
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<tr>
<td>D</td>
<td>790</td>
<td>8</td>
<td>832</td>
<td>16</td>
</tr>
<tr>
<td>death</td>
<td>260</td>
<td>8</td>
<td>238</td>
<td></td>
</tr>
</tbody>
</table>

We compare 3 interventions to the current screening.

- a test is offered at age 65 to people who have no history of screening (the rescue scenario).
- a test is offered at age 55 to those with no history of screening and at ages 65 and 75 to people who are not up to date with screening
- a test is offered at age 55 to those with no history of screening and at ages 55, 60, 65, 70 and 75 to people who are not up to date

Dukes’ stages A to D at detection. “death” means that the patient died in the same year that symptoms became apparent (they did not enter a surveillance program).
## Costs

<table>
<thead>
<tr>
<th>Stage</th>
<th>Initial phase</th>
<th>Continuing phase</th>
<th>Terminal phase</th>
<th>total costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28225</td>
<td>2246</td>
<td>50597</td>
<td>36157.6</td>
</tr>
<tr>
<td>B</td>
<td>38951</td>
<td>2093</td>
<td>50454</td>
<td>54741.42</td>
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<tr>
<td>C</td>
<td>47492</td>
<td>2992</td>
<td>53163</td>
<td>65331.35</td>
</tr>
<tr>
<td>D</td>
<td>62016</td>
<td>9275</td>
<td>71349</td>
<td>147206</td>
</tr>
</tbody>
</table>

- Annual costs of colorectal cancer (CRC) treatment, by stage and phase of care.
- with these costs and a cost of $200 per test we have a total cost of $2,289,754 per 100,000 people for a cost per QALY of $20,815
Thank You

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