

## Accepted Manuscript

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PII: S0091-7435(17)30414-0  
DOI: doi:[10.1016/j.ypped.2017.10.032](https://doi.org/10.1016/j.ypped.2017.10.032)  
Reference: YPMED 5202  
To appear in: *Preventive Medicine*  
Received date: 19 July 2017  
Revised date: 26 October 2017  
Accepted date: 30 October 2017

Please cite this article as: Emily He, Jie-Bin Lew, Sam Egger, Emily Banks, Robyn L. Ward, Valerie Beral, Karen Canfell , Factors associated with participation in colorectal cancer screening in Australia: Results from the 45 and Up Study cohort. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. *Ypmmed*(2017), doi:[10.1016/j.ypped.2017.10.032](https://doi.org/10.1016/j.ypped.2017.10.032)

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**Factors associated with participation in colorectal cancer screening in Australia: results from the 45 and Up Study cohort**

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**Keywords:** colorectal cancer, screening, National Bowel Cancer Screening Program, participation, uptake, iFOBT, FIT

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**Abstract**

The Australian Government's National Bowel Cancer Screening Program (NBCSP) was introduced in 2006 to provide free home-based immunochemical faecal occult blood test (iFOBT) to eligible Australians turning 55 and 65 years in that year. With the gradual inclusion of additional age cohorts, the rollout of the NBCSP is being implemented in the context of a degree of opportunistic screening being provided through primary care physicians.

This study investigated factors associated with ever-uptake of the NBCSP and of any CRC screening using questionnaire data from Australians aged  $\geq 45$  years enrolled in the 45 and Up Study.

Of the 91,968 study participants with information on CRC screening behaviour, 70,444 (76.6%) reported ever-uptake of any CRC screening. 63,777 study participants were eligible for a NBCSP invitation, of these 33,148 (52.0%) reported ever-uptake of screening through the NBCSP. Current smoking (RR=0.86, 0.83-0.90), non-participation in other cancer screening (RR=0.84, 0.81-0.86), poor self-reported health (RR=0.89, 0.86-0.91), lower levels of education (RR=0.91, 0.90-0.93), and not speaking English at home (RR=0.88, 0.85-0.91) were associated with reduced ever-uptake of screening the NBCSP and of any CRC screening. Individuals with a family history of CRC were less likely to screen through the NBCSP (RR= 0.71, 0.69-0.73), but more likely to participate in any CRC screening (RR= 1.18, 1.17-1.19).

Smokers, disadvantaged groups and those with non-English speaking backgrounds are less likely to have ever-participated in organised screening through the NBCSP or in any form of CRC screening, suggesting the need for specific strategies to improve uptake in these groups.

## Introduction

Colorectal cancer (CRC) is the second most common cancer in women and third most common cancer in men worldwide.<sup>1</sup> Australia has one of the highest incidences of CRC worldwide, with age-standardised rates of 67.6 and 48.8 per 100,000 in men and women respectively in 2013.<sup>1</sup> Trials have shown that screening with faecal occult blood test (FOBT) is effective at reducing disease-related mortality.<sup>2</sup>

In Australia, population-based CRC screening is provided through the Australian Government's National Bowel Cancer Screening Program (NBCSP). All citizens and permanent residents of Australia, as well as some temporary residents and refugees, receive an invitation letter, free immunochemical FOBT (iFOBT) kit and instructions on how to use it soon after they reach an eligible age. Different ages were targeted during various phases of the program. Phase 1 of the program went from August 2006 to June 2008 and it targeted people turning 55 and 65 years. Phase 2 went from July 2008 to June 2013 and it targeted people turning 50, 55 and 65 years. Phase 3 went from July 2013 to July 2015 and it targeted people turning 50, 55, 60 and 65 years. After July 2015, progressively more age groups between 50-74 years were invited and by 2020, the fully rolled out NBCSP will invite all people aged 50-74 years to screen with iFOBT every two years.

Participation rates in the NBCSP for those age cohorts invited to screen have remained at below 40% in the 10 years following commencement of rollout.<sup>3,4</sup> Analyses of the NBCSP produced by the Australian Institute of Health Welfare (AIHW) have shown lower rates of participation in younger invitation age groups, in people from the lower socioeconomic groups and in people living in remote areas.<sup>3,4</sup>

The rollout of the NBCSP is being implemented in the context of some level of opportunistic or *de facto* screening. In Australia, FOBT can be accessed via primary care physicians or available for purchase from pharmacies and non-government organisations. Colonoscopy is a procedure to

visually examine the bowel and is commonly performed to follow-up of positive screening results, screening and surveillance of colorectal polyps and cancers, and diagnosis or treatment of gastrointestinal conditions. It is widely available throughout Australia's public and private hospitals, with fees for the provision of colonoscopy services subsidised by the Australian government through the Medicare Benefits Schedule (MBS). There has been a marked growth in the provision of colonoscopies in Australia, with demand for MBS-funded colonoscopy (28% increase between 2009-10 and 2014-15) outstripping population growth (8% increase over the same period).<sup>5</sup> Although follow-up of positive results from the NBCSP can account for some of the increases in MBS-funded colonoscopy, it is probable that a substantial proportion of the procedures are being conducted as *de facto* screening tests.

The extent of out-of-program screening and the influence of sociodemographic factors other than those collected by the NBCSP on screening uptake are largely unknown. Furthermore, screening behaviour in relation to risk factors for CRC has not been characterised. A family history of CRC, smoking,<sup>6</sup> obesity,<sup>7</sup> alcohol consumption<sup>8</sup> are associated with increased risk for CRC. Observational studies have also shown that intake of red and processed increases the risk for CRC,<sup>9</sup> while a diet high in fruits and vegetables is associated with protection from CRC.<sup>10</sup>

In this context, therefore, the aim of the current analysis was to identify factors associated with CRC screening uptake using prospectively collected individual data in a large cohort study of people aged 45 years and over residing in Australia's most populous state (New South Wales, population 7.70 million).

## Methods

### Study population

The 45 and Up study cohort includes 267,153 adults aged 45 and over, residing in New South Wales (NSW), Australia. Prospective participants were sampled from the enrolment database of the Department of Human Services (formerly Medicare Australia), which administers Australia's publicly funded health insurance scheme. The conduct of the 45 and Up Study was approved by the University of New South Wales Human Research Ethics Committee. Information regarding the establishment and recruitment of the cohort is described elsewhere.<sup>11</sup>

Individuals joined the study in 2006-2009 by completing a questionnaire about sociodemographic, medical and lifestyle factors, and provided signed consent for long-term follow-up through repeated data collection. A follow-up questionnaire was mailed to participants in 2012-2015, a median of 5.2 years (SD 1.4 years) after recruitment, to determine how their health and lifestyles had changed over time. In the follow-up questionnaire, participants were asked: 'Have you ever been screened for colorectal (bowel) cancer?'. The screening tests encompassed in this question were FOBT, sigmoidoscopy and colonoscopy. They were further asked "Were you tested because you received an invitation to be screened for bowel cancer as part of the National Bowel Cancer Screening Program?" Using the respondent's month and year of birth, an individual was assumed to have received an invitation from the NBCSP if he/she was in an eligible birth cohort invited to screen as part of the NBCSP rollout, prior to completion of the questionnaire. Figure 1 shows the timing of the NBCSP rollout by age cohort in relation to the follow-up questionnaire.

### **Exposures assessed**

Data on age, self-rated health status, CRC screening behaviour, screening for other cancers (breast cancer screening in women and prostate cancer testing in men), and factors associated with an increased CRC risk (family history of CRC, smoking status, alcohol consumption, obesity, physical activity and diet) were derived from the follow-up questionnaire. Data on sociodemographic factors,

including gender, geographical remoteness of residence as measured by Accessibility-Remoteness Index of Australia Plus, socioeconomic disadvantage as measured by the Socio-Economic Indexes for Areas (SEIFA), education attainment, language spoken at home and country of birth were derived from information collected at the baseline questionnaire. Health insurance status was derived from information collected at the follow-up questionnaire.

### Statistical methods

This analysis uses questionnaire data from 105,897 participants who had responded to the follow-up questionnaire by February 2016. Poisson's regression with robust variance estimation was used to estimate the relative risk (RR) of ever-screening through the NBCSP among the study participants eligible for an invitation from the NBCSP prior to completion of the follow-up questionnaire, and of ever-screening for CRC among all the study participants who completed the follow-up questionnaire.<sup>12</sup> The dependent variables were uptake of CRC screening through the NBCSP (yes vs. no) in the first model and uptake of any CRC screening (yes vs. no) in the second model. Both models included the following independent variables: sociodemographic factors known to be associated with NBCSP participation (age, gender, geographical remoteness of residence, SEIFA) and those that were the focus of the current analysis (education, language spoken at home, migrant status and health insurance coverage), health factors (family history of CRC, body mass index, self-perceived health status,) and health behaviours (smoking status, alcohol intake, physical activity, dietary intake of red meat, processed meat, fruit and vegetables, as well as attendance at other cancer screening). Analyses relating to ever-screening through the NBCSP were additionally adjusted for the number of invitations a person was eligible to receive, while analyses relating to ever-screening for CRC were additionally adjusted for eligibility to receive an invitation from the NBCSP. Missing indicator categories were created for dependent variables. A  $\chi^2$  test for trend was used to test for significance



across exposure levels where appropriate. All analyses were performed using SAS® 9.4 (SAS Institute Inc., Cary, N.C.).

## Results

Of the 105,897 study participants who had completed the 45 and Up Study follow-up questionnaire, 13,926 were excluded from the analysis due to completely missing information on CRC screening behaviour, leaving 91,968 for analyses. Of these, 70,444 (76.6%) reported ever-screening for CRC (Table 1), including 32,324 (79.6%) men and 38,120 (74.2%) women. The proportion of study participants who reported ever-screening for CRC was highest in those aged 65-70 years (84.8%) and lowest in those aged 70 years and above (71.7%). Ever-participation in CRC screening was highest in those living in the least socioeconomically disadvantaged areas (80.0%) and lowest in those living the most socioeconomically disadvantaged areas (72.1%).

Among the 91,968 study participants with information on CRC screening behaviour, 63,777 were eligible for invitation from the NBCSP as it was rolled-out (Table 1). Of the 63,777 participants invited to participate in the NBCSP, 19% (11,810) had never undergone any CRC screening. 33,148 reported ever-screening through the NBCSP, which represents 36.0% of the entire study cohort and 52.0% of the study participants eligible for an invitation from the NBCSP. Of the study participants eligible for a NBCSP invitation, the proportion of people who reported ever-screening through the NBCSP was highest in those aged 55-59 years (54.8%), followed closely by those aged 60-64 years (52.3%), 65-70 years (52.1%) and 50-54 years (51.2%); it was lowest in those aged 70 years and above (46.3%). In each 5-year age group, the proportion of study participants who reported ever-screening through the NBCSP was greater in those who had received two invitations than those who had only received one. Ever-screening through the NBCSP was highest in those living in the least socioeconomically

disadvantaged (53.0%) and lowest in those living in the most socioeconomically disadvantaged areas (49.8%).

Lower levels of education and speaking a language other than English at home were associated with reduced uptake of CRC screening (Table 2). However, birth outside of Australia was not significantly associated with screening. Private health insurance coverage was not associated with ever-screening through the NBCSP (RR=1.02, 1.00-1.04 for those without vs. with private health insurance), but people without private health insurance were less likely to have had any CRC screening (RR=0.93, 0.92-0.94 for those without vs. with private health insurance). Compared to study participants with no family history of CRC, those with a family history were less likely to have had screening through the NBCSP (RR=0.71, 0.69-0.73), but were more likely to have had any CRC screening (RR=1.18, 1.17-1.19).

Current smokers were less likely to have ever had any CRC screening (RR=0.90, 0.870-0.92) and to screen through the NBCSP (RR=0.88, 0.83-0.92) than those who do not currently smoke (Table 3). However, body mass index and health behaviours such as physical activity, alcohol consumption and dietary intake of red meat, processed meat, fruit or vegetables did not have significant associations with uptake of CRC screening. People who did not attend screening for other cancers were less likely to participate in CRC screening, either through the NBCSP (RR=0.84, 0.81-0.86) or in any CRC screening (RR=0.79, 0.78-0.81), compared to those reporting they attended screening for other cancers. Those with poor or fair levels of self-rated health were less likely to participate in the NBCSP (RR=0.89, 0.86-0.91) compared to those with good or excellent levels of self-rated health, but self-reported health status had no significant relation to uptake of any CRC screening (RR=1.01, 0.99-1.02).

Of the 63,777 study participants who were eligible for an invitation from the NBCSP as it was rolled out, 33,148 (52.0%) reported ever-screening through the NBCSP and 18,819 (29.5%) reported ever-screening outside of the NBCSP. In those who ever-screened outside of the NBCSP, 10,572 (56.2%)

reported use of colonoscopy alone, 2691 (14.3%) reported use of FOBT alone, and 5278 (28.1%) reported used of both FOBT and colonoscopy, possibly as a result of diagnostic colonoscopy following positive FOBT and subsequent surveillance colonoscopy. Use of colonoscopy only in those who were eligible for NBCSP invitation but reported testing outside of the program was significantly associated with having private health insurance (RR=1.06, 1.03-1.11) and a family history of CRC (RR=1.24, 1.21-1.27).“

Overall, there were no significant gender differences in the associations between CRC screening and education, language, health insurance coverage, health status and health behaviours (Figure 2A-B).

## Discussion

We report the first comprehensive assessment of factors associated with ever-participation in CRC screening, either through a national population-based organised screening program, the NBCSP, or in any form of CRC screening. Individuals who were current smokers, did not attend screening for other cancers, had lower levels of education and did not speak English at home were less likely to have ever-participated in the NBCSP; these health behaviours and sociodemographic inequities were also associated with decreased likelihood of ever-participation in any CRC screening. Family history of CRC was associated with reduced uptake up organised screening through the NBCSP, but increased uptake of any CRC screening. Private health insurance coverage was not associated with ever-participation in the NBCSP, but those without private health insurance coverage were less likely to have had any CRC screening.

Our findings for the influence of health behaviours on CRC screening participation add to the limited evidence available. Studies based on CRC screening programmes in England, Finland and France,<sup>13-15</sup> as well as studies of CRC screening in the United States<sup>16 17</sup> have found similar associations between current smoking and non-participation in CRC screening. Our study did not find significant

associations between obesity and CRC screening uptake. Although earlier studies had found that being overweight or obese was associated with reduced participation in CRC screening,<sup>18-20</sup> more recent studies suggest that the prevalence of up-to-date CRC screening has increased in the last decade, and that being obese was associated with increased odds of CRC screening.<sup>21-22</sup> However, direct comparisons to our findings may be limited due to differences in health services delivery, as most other studies have been based on the U.S. population where CRC screening is conducted through physician recommendations.

Findings from our study and others have shown that screening behaviour for other cancers is predictive of participation in CRC screening; women who do not participate in breast cancer screening were less likely to undergo CRC screening, and men who do not participate in prostate cancer testing were less likely to undergo CRC screening.<sup>16-23</sup> Other health behaviours, such as regular physical exercise or dietary consumption of fruits, vegetables, red or processed meats were not found to be associated with participation. Participants who felt that their overall health were fair or poor were less likely to have had screening through the NBCSP compared to those with better ratings, possibly due to there being competing health priorities in those with poorer levels of health.

Multiple studies have shown that individuals from ethnic minorities are less likely to undergo screening for CRC, breast and cervical cancers,<sup>24-25</sup> and that language barrier was a key factor in screening disparities.<sup>26-28</sup> Our findings are consistent with these studies and provide the first individual-level evidence for language being a significant barrier to participation in the NBCSP in a large population-based study cohort. An earlier survey of 121 Australians from five culturally distinct groups found that individuals who are non-English speaking could not read the NBCSP invitation or understand the instructions for iFOBT sample collection, nor did they know that translations were available from the NBCSP website.<sup>26</sup> Therefore, culturally and linguistically appropriate interventions are required to improve screening participation in those from non-English-speaking backgrounds.

In our study, the proportion of people reporting ever having CRC screening is substantially higher than the proportion that ever ever-screening through the NBCSP (76.6% vs. 36.0%). This suggests that a sizeable proportion of the study population underwent screening outside of the NBCSP, partly because many (about one third) were not eligible for an invitation from the NBCSP as it was rolling out for the period covered by our analysis. With plans for the NBCSP to implement biennial iFOBT to all Australians aged 50-74 years by 2020, the number of invitations to screen through the NBCSP will increase considerably in the next three years.<sup>29</sup> In this environment, out-of-program screening may result in underutilisation of organised screening, cause duplication of services and potentially increase the cost of CRC screening.

Individuals with a family history of CRC may be more likely to engage in out-of-program screening, as our study found that individuals with a family history of CRC were more likely to undergo any CRC screening, but were less likely to screen through the NBCSP. A family history of CRC was also associated with use of colonoscopy alone in those who were eligible for an invitation from the NBCSP but reported testing outside of the program. In Australia, CRC screening guidelines for those with a family history of CRC are based on an assessment of the increased risk of CRC attributable to family history.<sup>30</sup> The latest revision of the Australian CRC screening guidelines, currently in draft, relates screening recommendations to absolute levels of risk based on the number of cancer affected family members, whether they are first-degree relatives and the age of onset of CRC in the relatives.<sup>31</sup> In particular, it seeks to discourage screening by colonoscopy in individuals who are categorised as 'slightly above average risk' of CRC, defined as having one first-degree or second-degree relative diagnosed with CRC at age 55 years or older.<sup>31</sup> This group, which constitutes the majority of individuals who have family history of CRC, have up to 2-fold the risk of CRC, a risk increase which the guidelines suggest do not warrant CRC screening by colonoscopy.<sup>31</sup>

Studies based on non-government funded CRC screening programmes have consistently shown that absence of health insurance coverage is associated with reduced uptake of CRC screening.<sup>15 32-35</sup> In

Australia, private health insurance supplements the federally-funded Medicare system and provides cover against some or all the costs associated with inpatient and outpatient medical treatments.<sup>36</sup>

Rates of private health insurance coverage are substantially lower in people from the lowest socioeconomic areas compared to people from the highest socioeconomic areas (33% vs.79%).<sup>37</sup> In our study, absence of private health insurance coverage was not associated with reduced ever-screening through the NBCSP, but those without private health insurance were less likely to have had any CRC screening. This indicates that the provision of free, population-based CRC screening through the NBCSP is effective in addressing one of the key socioeconomic factors associated with reduced CRC screening.

The proportion of study participants who reported ever-screening through the NBCSP cannot be directly compared with NBCSP data for several reasons. Our study looked at ever-screening through the NBCSP, whereas participation rates reported by the program are for people invited to screening within the preceding 24 months. Our study participants were divided into 5-year age groups based on their age at the time of follow-up questionnaire completion, and each 5-year age group is comprised of a varying mixture of people who were eligible for one or two invitations from the NBCSP at different ages. Therefore, the proportion of participants who reported ever-screening in the NBCSP differs to the participation rates in the various invitation age groups reported by the NBCSP.

In common with virtually all cohort studies, the 45 and Up Study cohort is more health conscious than the general population, and a previous study found that there was an overall tendency of colorectal test uptake to be associated with health-conscious behaviours.<sup>38</sup> Therefore, uptake of CRC screening in our study is likely to be greater than the general population and that absolute percentages found here are unlikely to be representative of the general population. Our finding of men having higher rates of ever-screening through the NBCSP than women differs from population-based participation rates reported by the NBCSP<sup>34,39</sup>. This may be explained by a greater differential

in the health-seeking behaviour between study participants and the general population for male participants than female participants. Nevertheless, comparisons from within the cohort, including the relative risks on factors affecting uptake of screening or its outcomes presented here, should remain valid even when the cohort is from a selected group.<sup>40</sup>

A limitation of our study is that screening history was derived from self-reported data, which could be affected by biases related to the accuracy of recall about screening history and to the social desirability of certain responses, potentially resulting in inaccurate reporting of screening.<sup>41</sup> A meta-analysis of validation studies on self-reported cancer screening uptake in the United States found that self-reported versus documented history of FOBT and colorectal endoscopy had reasonably high sensitivity (0.82 and 0.79, respectively) and specificity (0.78 and 0.90).<sup>42</sup> A survey of people living in England showed that self-reported ever uptake of CRC screening through the National Health Service Bowel Cancer Screening Programme was 94% accurate.<sup>43</sup> There may also be concern that although the questionnaire specifically asked about 'screening', participants may not be able to distinguish the difference between a screening and diagnostic test. However, a previous study has shown that most individuals who correctly recalled the testing history also accurately identified the reason for testing, with concordance of 80% for FOBT and 70% for endoscopy.<sup>44</sup> Furthermore, the associations we reported involving the NBCSP are likely to be specific to screening.

The use of prospectively collected personal data in a large cohort study brings new insight into factors related to participation in CRC screening, and specifically, screening through the NBCSP. The findings here demonstrate the influence of health behaviours on CRC screening uptake, which is important as behavioural risks for CRC may be compounded by reduced uptake of screening.

Strategies to incorporate CRC screening into health promotion initiatives targeting smoking and obesity may help to improve screening uptake in individuals with behavioural risks for CRC. The study findings also suggest that although there continues to be sociodemographic disparities in CRC screening participation, some are ameliorated by the implementation of a national population-based

screening program. However, disadvantaged groups and those from non-English-speaking backgrounds have reduced participation in the screening program, and further strategies to improve uptake in these groups are encouraged.

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**Acknowledgements**

“This research was completed using data collected through the 45 and Up Study ([www.saxinstitute.org.au](http://www.saxinstitute.org.au)). The 45 and Up Study is managed by the Sax Institute in collaboration with major partner Cancer Council NSW; and partners: the National Heart Foundation of Australia (NSW Division); NSW Ministry of Health; NSW Government Family & Community Services – Ageing, Carers and the Disability Council NSW; and the Australian Red Cross Blood Service. We thank the many thousands of people participating in the 45 and Up Study.

**Authors Contributions**

EH participated in the design of the study and lead the statistical analysis and writing of the article. SE assisted in sounding of data and statistical analysis. JBL, EB, RW and VB assisted in interpretation of results and review of the manuscript. KC led the design of the project, assisted in statistical analysis and reviewed and approved the final manuscript.

**Funding**

This work was funded via: National Health and Medical Research Council (NHMRC) Postgraduate Scholarship Grant (APP1093776) for EH, Australia Postgraduate Award (APA) PhD Scholarship for JBL, Translational Cancer Research Network (TCRN) Top-up scholarship, supported by Cancer Institute NSW for JBL, NHMRC Career Development Fellowship (CDFs APP1007994 and APP1082989) for KC.

**Role of funding source**

The study sponsors took no part in designing the study question or in the analysis or interpretation of results. They also did not take part in the writing of the article or in the decision to submit for publication.

**Conflict of Interest**

None

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**Table 1: Ever-uptake of CRC screening through the NBCSP and of any CRC screening, by sociodemographic characteristics of 45 and Up study participants<sup>a</sup>**

	CRC screening through the NBCSP		Any CRC screening (includes screening outside the NBCSP)	
	Total number eligible for NBCSP invitation	% screened	Total number eligible	% screened
<b>Gender</b>				
Male	26985	55.3%	40580	79.6%
Female	36792	49.6%	51388	74.2%
<b>Age at follow-up</b>				
50 – 54	11203	51.2%	11341	73.2%
<i>One NBCSP invitation</i>	11114	51.1%		
<i>Two NBCSP invitations</i>	89	56.2%		
55 – 59	16895	54.8%	16896	80.4%
<i>One NBCSP invitation</i>	13427	50.7%		
<i>Two NBCSP invitations</i>	3468	70.8%		
60 – 64	10927	52.3%	18262	75.3%
<i>One NBCSP invitation</i>	7215	44.7%		
<i>Two NBCSP invitations</i>	3712	67.1%		
65 – 70	16891	52.1%	16892	84.8%
<i>One NBCSP invitation</i>	16860	52.1%		
<i>Two NBCSP invitations</i>	31	67.7%		
70+	7861	46.3%	28577	71.7%
<i>One NBCSP invitation</i>	7639	45.9%		
<i>Two NBCSP invitations</i>	222	59.5%		
<b>Area of residence</b>				
Metropolitan areas	32154	51.1%	46498	75.9%
Non-metropolitan areas	31623	52.9%	45470	77.3%
<b>Socio-Economic Indexes for Areas (SEIFA)</b>				
Least disadvantaged (quintile 5)	15508	53.0%	21490	80.0%
Second least disadvantaged (quintile 4)	11622	52.8%	16250	78.2%
Middle (quintile 3)	12154	52.3%	17399	76.5%
Second most disadvantaged (quintile 2)	12264	52.2%	18201	75.1%
Most disadvantaged (quintile 1)	10304	49.8%	15912	72.1%
<b>Total<sup>b</sup></b>	<b>63777</b>	<b>52.0%<sup>c</sup></b>	<b>91968</b>	<b>76.6%</b>

<sup>a</sup> Variables are derived from responses to the 45 and Up baseline questionnaire, unless stated otherwise<sup>b</sup> For each variable, the numbers of participants with missing responses are not shown.<sup>c</sup> 33,148 of 63,777 reported ever-screening through the NBCSP, which represents 36.0% of the entire study cohort and 52.0% of the study participants eligible for an invitation from the NBCSP.



**Table 2: Comparison of factors associated with ever-uptake of screening through the NBCSP and of any CRC screening, among participants of the 45 and Up Study<sup>a</sup>**

Variable	CRC screening through the NBCSP <sup>b</sup>			Any CRC screening <sup>c</sup> (includes screening outside the NBCSP)		
	Total n <sup>d</sup>	% screened	RR (95% CI)	Total n	% screened	RR (95% CI)
<b>Education level</b>						
Post-high school qualifications	41917	54.3%	1.00	57306	79.9%	1.00
Up to and including HSC	21452	47.6%	<b>0.91 (0.90 - 0.93)</b>	33894	71.4%	<b>0.94 (0.93 - 0.94)</b>
<b>Language spoken at home</b>						
English only	59600	52.3%	1.00	86108	77.4%	1.00
Non-English	4177	46.8%	<b>0.88 (0.85 - 0.91)</b>	5863	65.5%	<b>0.89 (0.87 - 0.90)</b>
<b>Country of Birth</b>						
Australia	50256	51.9%	1.00	71911	77.7%	1.00
Overseas	13281	52.2%	1.02 (1.00 - 1.04)	19614	72.8%	<b>0.97 (0.96 - 0.98)</b>
<b>Private health insurance at follow-up</b>						
No	15539	50.6%	1.00	66592	79.5%	1.00
Yes	47275	52.5%	1.02 (1.00 - 1.04)	23636	68.8%	<b>0.93 (0.92 - 0.94)</b>
<b>Family history of bowel cancer at follow-up</b>						
No	53773	54.4%	1.00	77029	74.3%	1.00
Yes	9984	38.8%	<b>0.71 (0.69 - 0.73)</b>	14877	88.6%	<b>1.18 (1.17 - 1.19)</b>

<sup>a</sup> Variables are derived from responses to the 45 and Up baseline questionnaire, unless stated otherwise

<sup>b</sup> Model included independent variables gender, age, number of invitations received from the NBCSP, area of residence, SEIFA, education, language spoken at home, country of birth, private health insurance status, family history of bowel cancer, self-reported health status, screening for other cancers, smoking status, alcohol consumption, physical activity, BMI, as well as dietary intake of processed meat, red meat, fruits and vegetables.

<sup>c</sup> Model included independent variables gender, age, eligibility to receive an invitation from the NBCSP, area of residence, SEIFA, education, language spoken at home, country of birth, private health insurance status, family history of bowel cancer, self-reported health status, screening for other cancers, smoking status, alcohol consumption, physical activity, BMI, as well as dietary intake of processed meat, red meat, fruits and vegetables.

<sup>d</sup> For each variable, the number of participants with missing responses are not shown.

**Table 3: Health behaviours and health factors associated with ever-uptake of CRC screening through the NBCSP and of any CRC screening, among participants of the 45 and Up study<sup>a</sup>**

Variables	CRC screening through the NBCSP <sup>b</sup>			Any CRC screening <sup>c</sup> (includes screening outside the NBCSP)		
	Total n <sup>d</sup>	% screened	RR (95% CI)	Total n	% screened	RR (95% CI)
<b>Screening for other cancers</b>						
Yes	56946	52.7%	1.00	81669	78.5%	1.00
No	6397	45.3%	<b>0.84 (0.81 - 0.86)</b>	9390	60.6%	<b>0.79 (0.78 - 0.81)</b>
<b>Smoking status</b>						
Not current smoker	60396	52.4%	1.00	87634	77.1%	1.00
Current smoker	3014	43.8%	<b>0.86 (0.83 - 0.90)</b>	3660	65.4%	<b>0.89 (0.86 - 0.91)</b>
<b>Alcohol consumption</b>						
≤ 14 drinks/week	35348	53.2%	1.00	49765	78.5%	1.00
> 14 drinks/week	9334	52.8%	0.98 (0.96 - 1.00)	12394	81.1%	1.01 (1.00 - 1.02)
Non-drinkers	18269	49.5%	0.98 (0.97 - 1.00)	28186	72.1%	0.97 (0.96 - 0.98)
<b>Physical activity<sup>e</sup></b>						
Meets guidelines	46841	52.8%	1.00	67079	77.8%	1.00
Does not meet guidelines	16936	49.7%	0.96 (0.95 - 0.98)	24892	73.5%	0.98 (0.97 - 0.98)
<b>Body Mass Index (kg/m<sup>2</sup>)</b>						
Not overweight (< 25)	25064	53.0%	1.00	36069	77.2%	1.00
Overweight (≥ 25)	31658	51.6%	0.95 (0.93 - 0.97)	44754	77.3%	0.97 (0.96 - 0.98)
<b>Consumption of processed meat</b>						
≤ 1 serve/week	43610	51.5%	1.00	62530	76.5%	1.00
> 1 serve/week	19812	52.9%	1.01 (0.99 - 1.03)	28756	76.7%	0.99 (0.99 - 1.00)
<b>Consumption of red meat</b>						
≤ 2 serves/week	26163	50.9%	1.00	37237	75.2%	1.00
> 2 serves/week	37234	52.8%	1.03 (1.01 - 1.05)	54012	77.5%	1.01 (1.00 - 1.02)
<b>Consumption of fruit</b>						
< 2 serves/day	17578	51.1%	1.00	24129	76.0%	1.00
≥ 2 serves/day	44597	52.5%	1.02 (1.00 - 1.04)	65487	77.0%	1.01 (1.00 - 1.02)
<b>Consumption of vegetables</b>						
< 5 serves/day	41243	52.3%	1.00	58538	76.7%	1.00
≥ 5 serves/day	21602	51.6%	1.01 (0.99 - 1.03)	31853	76.8%	1.01 (1.00 - 1.01)
<b>Self-rated health status</b>						
Good or excellent	56776	52.8%	1.00	79826	77.3%	1.00
Fair or poor	6406	44.3%	0.89 (0.86 - 0.91)	10993	71.7%	1.01 (0.99 - 1.02)

<sup>a</sup> Variables are derived from responses to the 45 and Up follow-up questionnaire<sup>b</sup> Model included independent variables number of invitations received from the NBCSP, gender, age, area of residence, SEIFA, education, language spoken at home, country of birth, private health insurance status, family history of bowel cancer, self-reported health status, screening for other cancers, smoking status, alcohol consumption, physical activity, BMI, as well as dietary intake of processed meat, red meat, fruits and vegetables.<sup>c</sup> Model included independent variables gender, age, eligibility to receive an invitation from the NBCSP, area of residence, SEIFA, education, language spoken at home, country of birth, private health insurance status, family history of bowel cancer, self-reported health status, screening for other cancers, smoking status, alcohol consumption, physical activity, BMI, as well as dietary intake of processed meat, red meat, fruits and vegetables.<sup>d</sup> For each variable, the number of participants with missing responses are not shown.<sup>e</sup> Australia's Physical Activity and Sedentary Behaviour Guidelines<sup>44</sup>

**Figure 1****Caption:**

Figure 1. National Bowel Cancer Screening Program Age Eligibility by Year of Birth

**Legend:**

Figure 1 shows the timing of the NBCSP rollout for specific age cohorts and mailout of the follow-up questionnaire from the 45 and Up study.

**Figure 2A-B****Caption:**

Figure 2A. Comparison of factors associated with CRC screening through the NBCSP in men and women from the 45 and Up study<sup>#</sup>

Figure 2B. Comparison of factors associated with any CRC screening in men and women from the 45 and Up study<sup>#</sup>

**Legend:**

Figure 2A shows a comparison of factors associated with CRC screening through the NBCSP in men and women from the 45 and Up study. Figure 2B shows a comparison of factors associated with any CRC screening in men and women from the 45 and Up study.

Figure 1. National Bowel Cancer Screening Program Age Eligibility by Year of Birth

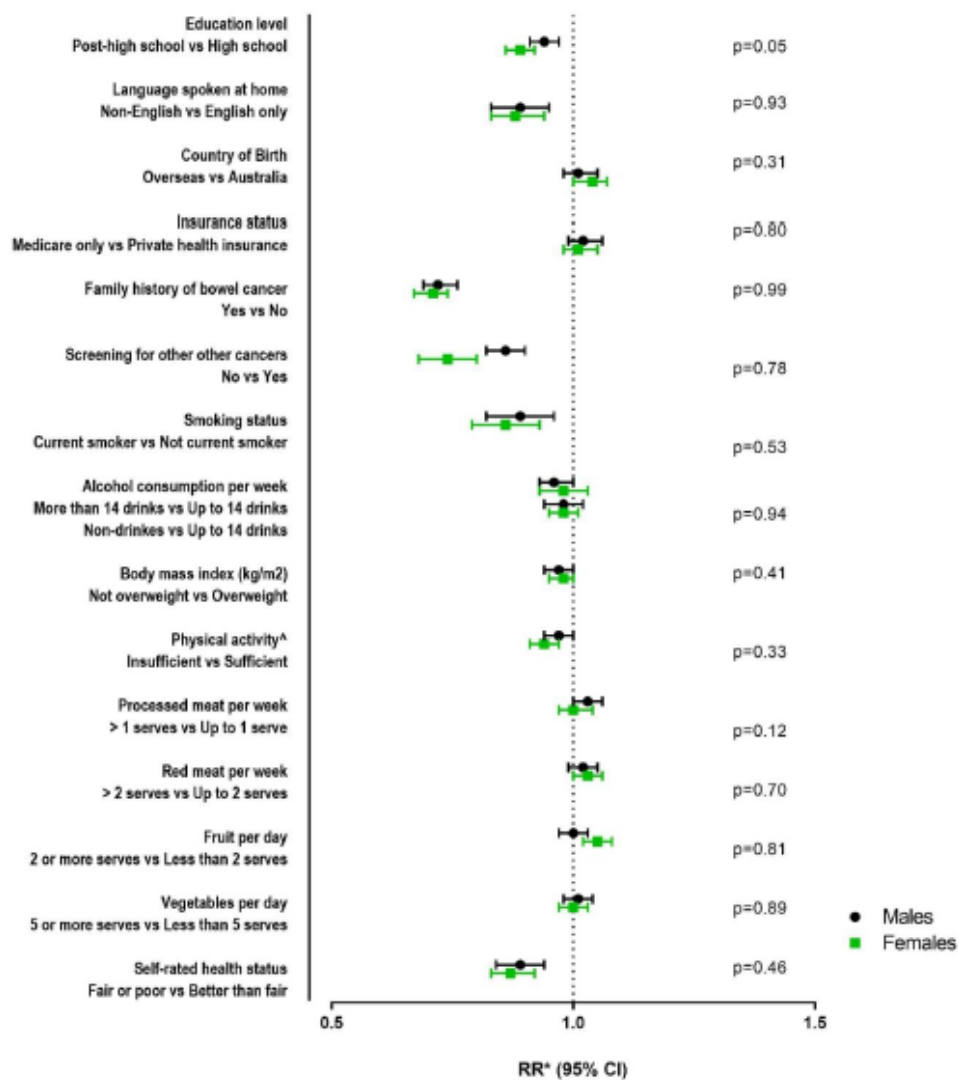
Shaded box indicates age cohorts invited to participate in the NBCSP from 1 January in each year

Follow-up questionnaires were sent in 2012-2015. Responses received by Feb 2016 were used for this analysis.

Year of birth	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1941	65	66	67	68	69	70	71	72	73	74	75
1942	64	65	66	67	68	69	70	71	72	73	74
1943	63	64	65	66	67	68	69	70	71	72	73
1944	62	63	64	65	66	67	68	69	70	71	72
1945	61	62	63	64	65	66	67	68	69	70	71
1946	60	61	62	63	64	65	66	67	68	69	70
1947	59	60	61	62	63	64	65	66	67	68	69
1948	58	59	60	61	62	63	64	65	66	67	68
1949	57	58	59	60	61	62	63	64	65	66	67
1950	56	57	58	59	60	61	62	63	64	65	66
1951	55	56	57	58	59	60	61	62	63	64	65
1952	54	55	56	57	58	59	60	61	62	63	64
1953	53	54	55	56	57	58	59	60	61	62	63
1954	52	53	54	55	56	57	58	59	60	61	62
1955	51	52	53	54	55	56	57	58	59	60	61
1956	50	51	52	53	54	55	56	57	58	59	60
1957	49	50	51	52	53	54	55	56	57	58	59
1958	48	49	50	51	52	53	54	55	56	57	58
1959	47	48	49	50	51	52	53	54	55	56	57
1960	46	47	48	49	50	51	52	53	54	55	56
1961	45	46	47	48	49	50	51	52	53	54	55
1962	44	45	46	47	48	49	50	51	52	53	54
1963	43	44	45	46	47	48	49	50	51	52	53
1964	42	43	44	45	46	47	48	49	50	51	52

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Figure 2A. Comparison of factors associated with CRC screening through the NBCSP in men and women from the 45 and Up study<sup>a</sup>

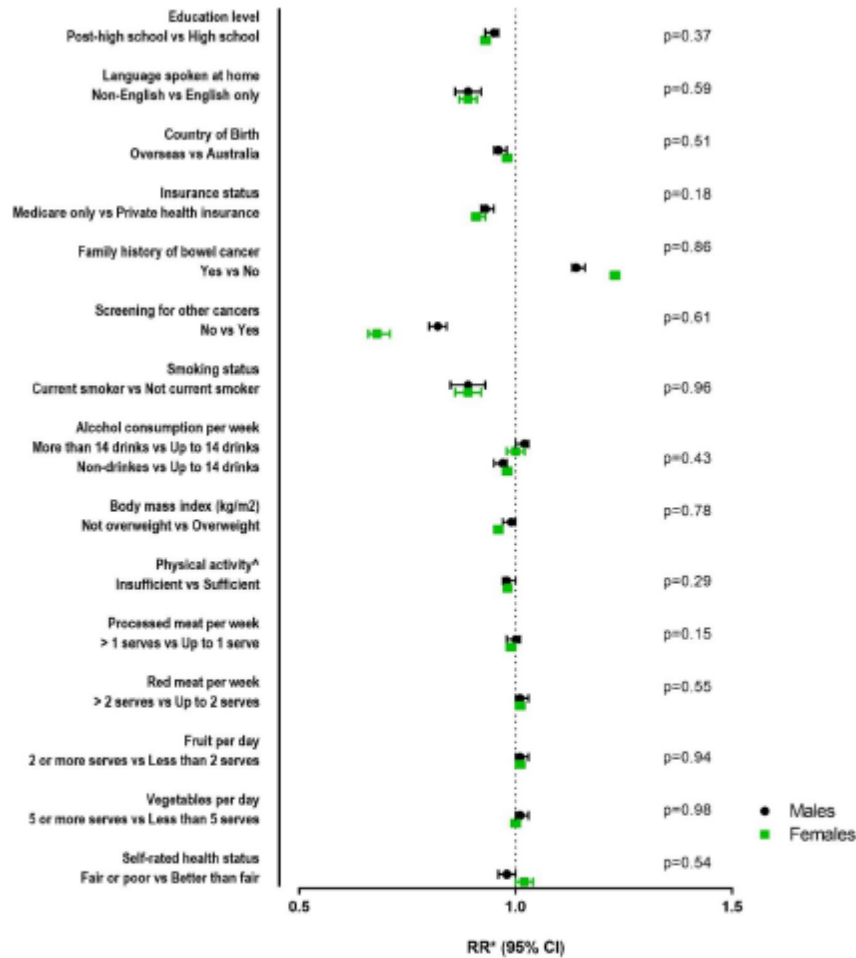


<sup>a</sup> p values are for interaction between gender and listed variable

<sup>\*</sup> Model included the independent variables age, number of invitations received from the NBCSP, area of residence, SEIFA, education, language spoken at home, country of birth, private health insurance status, family history of bowel cancer, self-reported health status, screening for other cancers, smoking status, alcohol consumption, physical activity, BMI, as well as dietary intake of processed meat, red meat, fruits and vegetables.

<sup>^</sup> Australia's Physical Activity and Sedentary Behaviour Guidelines<sup>44</sup>

Figure 2B. Comparison of factors associated with any CRC screening in men and women from the 45 and Up study\*



\* p values are for interaction between gender and listed variable

† Model included the independent variables for gender, age, eligibility to receive an invitation from the NBCSP, area of residence, SEIFA, education, language spoken at home, country of birth, private health insurance status, family history of bowel cancer, self-reported health status, screening for other cancers, smoking status, alcohol consumption, physical activity, BMI, as well as dietary intake of processed meat, red meat, fruits and vegetables.

‡ Australia's Physical Activity and Sedentary Behaviour Guidelines<sup>44</sup>

## Highlights

- Smokers were less likely to have ever-screened for CRC
- Those who were less likely to screen for breast cancer (or have PSA testing) to have ever-screened for CRC
- Lower levels of education and non-English speakers were associated with lower uptake of CRC screening
- Private health insurance coverage was not associated with uptake of screening through the NBCSP
- A sizeable proportion of the study population underwent some form of CRC testing outside of the NBCSP

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