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# Lifestyle and occupational factors associated with participation in colorectal cancer screening among men and women in Australia

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ABSTRACT

This study explores the associations between lifestyle and occupational factors and participation in colorectal cancer (CRC) screening among men and women aged 50 and over and living in Australia. We used weighted data from the Australian National Health Survey 2014–15 to produce population estimates. Lifestyle variables investigated were smoking, physical activity, alcohol consumption, fruit and vegetable consumption, and body mass index, while the occupational variables were labour force status, occupation, and participation in shift work. Using weighted data, 1,990,287 men (55%) and 1,898,232 women (49%) reported ever-screening for CRC. Female current smokers were less likely to report ever-screening for CRC (adjusted RR = 0.78, 95% CI 0.64–0.96), as were men who were less physically active (aRR = 0.87, 95% CI 0.78–0.97), reported no alcohol consumption (aRR = 0.73, 95% CI 0.59–0.91), and reported eating more vegetables (aRR = 0.84, 95% CI 0.72–0.99). When lifestyle behaviours were combined into a healthy lifestyle index score, a significant trend was observed for both men and women, whereby those who reported engaging in more healthy behaviours were more likely to have ever-screened for CRC ($p = .027$ men; $p < .001$ women). No associations were observed between CRC screening and occupational variables. This is the first comprehensive assessment of the lifestyle and occupational factors associated with participation in CRC screening among men and women in Australia. Participation in CRC screening was greater among those engaging in more healthy behaviours, suggesting that an individual's pattern of lifestyle behaviours may be important in determining screening participation. These results have important implications for public health strategies on improving CRC screening participation.

## 1. Introduction

Colorectal cancer (CRC) is the third most commonly diagnosed cancer in Australia, with an estimated 47 new cases being diagnosed each day (Australian Institute of Health and Welfare, 2018a). It accounts for approximately 12.3% of all cancers diagnosed in Australia each year. CRC is more common in men than women, with an age-standardised incidence rate of 66.7 per 100,000 in men and 49.2 per 100,000 in women. Approximately two-thirds (69.4%) of those diagnosed in 2010–2014 were still alive at five years post-diagnosis (Australian Institute of Health and Welfare, 2018a), with survival being highly dependent on stage at diagnosis (Levin et al., 2008).

Trials have demonstrated that screening (via either flexible sigmoidoscopy or faecal occult blood testing (iFOBT)) increases the detection of early stage cancers and reduces mortality from CRC (Holme et al., 2013). In Australia, the National Bowel Cancer Screening Program (NBCSP) provides government-funded, population-based CRC screening for Australian residents aged between 50 and 74 using an iFOBT (Australian Institute of Health and Welfare, 2018b). All eligible Australians are sent an iFOBT screening kit every two years, with results returned to the participant, their nominated health care provider, and the NBCSP register.

Since the NBCSP began in 2006, approximately 4.4 million CRC screening tests have been completed (Australian Institute of Health and Welfare, 2018b). The latest participation rates show that 41% of eligible invitees (1.3 million people) participated in 2015–16. This is a slight increase from the participation rate (39%) reported for the previous two-year period. Those more likely to screen for CRC included women, those living in inner regional areas, and those living in the highest socioeconomic areas. Participation also increased with age, from 28.1% for those aged 50–54 to 52.5% for those aged 70–74.

Various demographic and health factors have been found to be associated with participation in CRC screening. For example, lower education levels, speaking a foreign language, lower socioeconomic status, and not having private health insurance have been associated with lower rates of screening participation (Blanks et al., 2015; He et al.,

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2018; Weber et al., 2008). Participation in other health screening, including screening for other cancers, has also been associated with a greater likelihood of CRC screening (Shapiro et al., 2001; Weber et al., 2008). Further, recent Australian studies have found a higher likelihood of CRC screening among those with a previous cancer diagnosis (Varlow et al., 2014) and family history of CRC (He et al., 2018).

It has also been hypothesised that participation in CRC screening may be associated with adherence to other health behaviours such as smoking and physical activity (Wools et al., 2016). While these factors have been found to be associated with CRC risk, few studies have investigated their association with CRC screening participation (He et al., 2018). The most consistent evidence has been found for smoking, with non-smokers consistently being found to be more likely to participate in CRC screening (Blanks et al., 2015; He et al., 2018; Shapiro et al., 2001; Weber et al., 2008). A recent Australian study found that those who were overweight, who participated in lower levels of physical activity, and who did not consume alcohol were less likely to participate in CRC screening (He et al., 2018). Similarly, a large UK study found that overweight women were less likely to accept a CRC screening invitation, while those who participated in strenuous exercise and consumed more alcohol were more likely to accept the invitation (Blanks et al., 2015). There is also accumulating evidence that adhering to a greater number of healthy lifestyle factors is associated with a reduced risk of CRC (e.g. Kirkegaard et al., 2010; Zhang et al., 2018); however, there is limited evidence on whether adhering to a greater number of healthy lifestyle factors impacts CRC screening participation rates.

Limited evidence also suggests that participation in CRC screening may be associated with occupational factors including employment status (Weber et al., 2013), hours of work (Nicholls et al., 2017), and shift work status (Son and Kang, 2017; Tsai et al., 2014). An Australian study, for example, found that uptake of CRC screening among nurses and midwives was lower among full-time and shift workers (as opposed to part-time and non-shift workers, respectively) (Nicholls et al., 2017). Similarly, a study in the US found that women who work alternative shifts were less likely to participate in CRC screening as compared with those working daytime shifts (Tsai et al., 2014).

The aim of the current study is to further investigate the lifestyle and occupational factors associated with participation in CRC screening among Australian men and women using a large national dataset.

## 2. Methods

### 2.1. Study population

We used data from the 2014–15 National Health Survey, a household-based survey conducted by the Australian Bureau of Statistics (ABS). Data were collected in-person by trained interviewers. Full details of the survey methodology have been provided elsewhere (Australian Bureau of Statistics, 2015). The 2014–15 survey included 19,259 individuals from 14,723 households, a response rate of 82%. We analysed data from adults aged 50 years and over (n = 6937, 45.7% men) in line with the current CRC screening recommendations.

### 2.2. Exposures assessed

Participation in CRC screening was derived from two questions: “What type(s) of cancer have you been tested for in the last two years?” (screening in the last two years) and “What type(s) of cancer have you ever been tested for?” (ever screening). Those providing the response option “bowel (e.g. had a faecal occult blood test)” were assessed as having participated in CRC screening. As CRC screening is currently recommended every two years in Australia (Australian Institute of Health and Welfare, 2018b), we investigated the factors associated with both screening in the last two years (to reflect those screening in line with recommendations) as well as ever-screening.

We used data on the sociodemographic variables of age, highest level of educational attainment, country of birth (Australia or other), main language spoken in the home (English or other), and household income (classified into quintiles), as well as area of residence (dichotomised into metropolitan or non-metropolitan). We also assessed the following health variables: number of general practitioner (GP) visits in the last year (dichotomised at the median), private health insurance status (yes/no), personal history of cancer diagnosis (yes/no), ever participation in any other cancer screening (including breast, prostate, and cervical; condensed into yes/no), and the performance of regular skin cancer checks (yes/no).

The lifestyle variables we assessed comprised smoking status, physical activity, alcohol consumption, fruit and vegetable consumption, and body mass index. Smoking status was classified as current, former, or never, with former and never smokers combined into a single group for analysis. Physical activity was assessed according to whether the individual met the 2014 Australian physical activity guidelines for their age group (Department of Health, 2017), taking into account time spent in moderate and vigorous physical activity in the last week. Alcohol consumption was assessed as the number of standard drinks consumed in the last week (classified as $\leq 14$, $> 14$, or non-drinker). Fruit and vegetable consumption were assessed according to ‘usual’ serves of fruit and vegetables consumed per day and dichotomised according to the Australian dietary guidelines (National Health and Medical Research Council, 2013). Body mass index was based on physical weight and height measurements taken as part of the interview and trichotomised into not overweight ($< 25\,kg/m^2$), overweight ($25 < 30\,kg/m^2$) and obese ($\geq 30\,kg/m^2$).

We also used data on three occupational variables: labour force status (employed, unemployed, or not in labour force); occupation (according to the 2-digit Australian and New Zealand Standard Classification of Occupations (ANZSCO) (Australian Bureau of Statistics, 2009)); and shift work status. Shift work status was based on the question “Did you do any shift work at any time during the last 4 weeks?” and classified as yes or no. No further definition of shift work was given, although information was also collected on the pattern of shift performed. Those indicating “regular evening, night or graveyard shift” pattern were classified as performing night shift work in our analyses.

### 2.3. Statistical analysis

The ABS provides individual person weights to be used when calculating population estimates from National Health Survey data (Australian Bureau of Statistics, 2017). These weights take into account the probability of a person being selected for interview and are calibrated against the population benchmarks of age, sex, and usual area of residence to ensure that estimates reflect the distribution of the Australian resident population. We used these weights in all analyses using the ‘survey’ command in Stata 14 (College Station, Texas).

We used modified Poisson regression with robust variance estimation (Zou, 2004) to assess the relative risk and 95% confidence intervals (CI) of participating in CRC screening (ever or in the last two years) by lifestyle and occupational variables. As participation in CRC screening has been found to vary by gender, analyses were stratified by gender. We adjusted for age, highest level of education, country of birth, language spoken at home, area of residence, income, GP visits, private health insurance, ever diagnosis of cancer, participation in other cancer screening, and regular performance of skin checks, as well as lifestyle variables where relevant.

We also created a healthy lifestyle index based on the six lifestyle variables investigated. We used a binary score (0/1) for each factor whereby a score of 1 indicated healthier behaviour (i.e. not a current smoker; meeting physical activity guidelines; alcohol consumption of $\leq 14$ standard drinks or non-drinker; vegetable consumption of $\geq 5$ serves/day; fruit consumption of $\geq 2$ serves/day; and BMI $< 25\,kg/m^2$). We then summed the binary score for each of the

**Table 1**
Colorectal cancer screening (ever and within the last two years) among men and women living in Australia 2014–15, by sociodemographic and health characteristics (weighted data).

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Total number eligible[a] | Screened in last 2 years, % (95% CI) | Ever screened, % (95% CI) | Total number eligible[a] | Screened in last 2 years, % (95% CI) | Ever screened, % (95% CI) |
| Total | 3,625,296 | 33.6 (31.5–35.7) | 54.9 (52.6–57.1) | 3,866,053 | 26.1 (24.3–27.9) | 49.1 (47.1–51.1) |
| Age group | | | | | | |
| 50–64 | 2,067,186 | 34.8 (31.9–37.8) | 52.6 (49.5–55.7) | 2,139,614 | 27.9 (25.4–30.5) | 49.3 (46.5–52.2) |
| 65 + | 1,558,110 | 32.0 (29.1–35.0) | 57.9 (54.6–61.0) | 1,726,439 | 23.8 (21.5–26.3) | 48.8 (45.9–51.7) |
| Highest level of education | | | | | | |
| Post-high school | 2,200,068 | 35.2 (32.4–38.0) | 57.0 (54.1–59.9) | 1,745,470 | 29.9 (27.2–32.8) | 54.6 (51.4–57.7) |
| High school or lower | 1,371,438 | 30.5 (27.3–33.8) | 50.8 (47.3–54.4) | 2,023,775 | 22.7 (20.5–25.1) | 44.4 (41.7–47.2) |
| Country of birth | | | | | | |
| Australia | 2,411,543 | 35.5 (32.9–38.1) | 58.5 (55.8–61.2) | 2,550,912 | 27.2 (25.1–29.5) | 51.9 (49.4–54.3) |
| Other | 1,213,754 | 29.8 (26.3–33.4) | 47.6 (43.7–51.5) | 1,315,141 | 23.9 (21.0–27.0) | 43.7 (40.2–47.3) |
| Main language spoken at home | | | | | | |
| English | 3,209,965 | 34.5 (32.3–36.7) | 57.3 (55.0–59.5) | 3,453,477 | 27.1 (25.3–29.0) | 51.5 (49.4–53.6) |
| Other | 415,332 | 26.4 (20.1–33.8) | 36.2 (29.2–43.8) | 412,576 | 17.4 (12.5–23.6) | 28.7 (22.8–35.5) |
| Area of residence | | | | | | |
| Metropolitan | 2,403,618 | 31.3 (28.8–33.9) | 52.4 (49.6–55.2) | 2,637,063 | 26.3 (24.2–28.6) | 48.2 (45.7–50.7) |
| Non-metropolitan | 1,221,678 | 38.1 (34.5–41.8) | 59.7 (56.0–63.3) | 1,228,990 | 25.6 (22.6–28.8) | 50.9 (47.4–54.5) |
| Household income | | | | | | |
| Lowest quintile | 631,392 | 29.8 (25.5–34.6) | 49.5 (44.6–54.3) | 808,824 | 20.7 (17.6–24.2) | 44.3 (40.3–48.4) |
| Second quintile | 631,845 | 29.8 (25.5–34.5) | 57.7 (52.6–62.7) | 763,290 | 26.2 (22.6–30.2) | 51.6 (47.3–56.0) |
| Middle quintile | 550,825 | 37.7 (32.4–43.3) | 53.4 (47.7–59.0) | 499,159 | 29.7 (24.6–35.3) | 48.0 (42.2–53.8) |
| Fourth quintile | 451,372 | 36.3 (30.5–42.5) | 55.2 (48.7–61.6) | 428,456 | 28.7 (23.3–34.8) | 55.0 (48.5–61.4) |
| Highest quintile | 548,715 | 43.4 (37.7–49.3) | 66.5 (60.8–71.8) | 410,851 | 32.7 (26.9–39.1) | 53.4 (46.8–59.9) |
| GP visits in last year | | | | | | |
| < 4 visits | 1,794,258 | 33.0 (30.0–36.2) | 51.5 (48.2–54.8) | 1,683,991 | 26.5 (23.9–29.4) | 50.1 (47.0–53.3) |
| ≥4 visits | 1,831,039 | 34.1 (31.3–37.1) | 58.1 (55.1–61.1) | 2,182,062 | 25.7 (23.5–28.1) | 48.3 (45.6–51.0) |
| Private health insurance status | | | | | | |
| Yes | 2,165,491 | 37.5 (34.7–40.4) | 60.3 (57.3–63.1) | 2,358,556 | 29.8 (27.4–32.2) | 54.5 (51.9–57.1) |
| No | 1,467,863 | 27.8 (24.8–31.0) | 47.0 (43.5–50.4) | 1,506,408 | 20.4 (17.9–23.1) | 40.6 (37.5–43.8) |
| Personal history of cancer | | | | | | |
| Yes | 827,778 | 35.9 (31.7–40.3) | 63.8 (59.3–68.1) | 835,156 | 28.1 (24.4–32.1) | 56.0 (51.7–60.3) |
| No | 2,797,518 | 32.9 (30.5–35.3) | 52.2 (49.6–54.8) | 3,030,897 | 25.5 (23.6–27.6) | 47.2 (44.9–49.5) |
| Participation in other cancer screening | | | | | | |
| Yes | 2,113,393 | 41.7 (38.9–44.5) | 68.5 (65.7–71.1) | 3,256,639 | 29.6 (27.6–31.6) | 55.8 (53.6–58.0) |
| No | 1,511,903 | 22.3 (19.4–25.5) | 35.8 (32.5–39.4) | 609,414 | 7.5 (5.2–10.6) | 13.0 (10.1–16.7) |
| Regularly perform skin cancer check | | | | | | |
| Yes | 2,424,457 | 36.4 (33.9–39.0) | 59.9 (57.3–62.6) | 2,777,347 | 28.2 (26.2–30.4) | 53.0 (50.6–55.4) |
| No | 1,196,291 | 27.7 (24.1–31.6) | 44.5 (40.5–48.5) | 1,079,117 | 20.7 (17.8–24.1) | 39.4 (35.7–43.3) |

[a] Extrapolated to Australian population using survey weights derived by Australian Bureau of Statistics.

factors to create a lifestyle index which ranged from 0 (least healthy) to 6 (most healthy). As there were a small number of individuals practicing 5 or 6 healthy behaviours, we combined the scores into 4 categories (0–1, 2, 3, and 4–6 factors). A test for trend was conducted by entering the original healthy lifestyle index score into the model as a continuous variable.

We conducted a sensitivity analysis whereby fruit and vegetable consumption were excluded from the healthy lifestyle index, as these factors have not been associated with CRC risk. We combined scores on this index into 3 categories (0–1, 2, 3–4).

## 3. Results

Using weighted data, a total of 3,888,519 (51.9% of eligible) individuals reported ever-screening for CRC, including 1,990,287 (54.9%) men and 1,898,232 (49.1%) women (Table 1). Results using unweighted data showed no difference (data not shown) and so only weighted results are shown here. A total of 2,227,139 individuals had screened for CRC in the last two years (1,218,099 men and 1,009,040 women). Patterns of CRC screening participation were similar for ever-screening and screening within the last two years. For both time frames, participation rates were higher in those born in Australia and speaking English as their main language. CRC screening participation also varied by income, with higher participation rates in those reporting a higher income, and private health insurance status, with those having private health insurance reporting higher participation rates than those with no insurance. Participation also differed by health variables, with higher participation rates in those with a personal history of cancer, participating in other forms of cancer screening, and performing regular skin cancer checks.

With regard to lifestyle behaviours, current smokers were significantly less likely to report screening for CRC than former or never smokers for both men (screening in last two years only; Table 2) and women (Table 3). Among men, those who did not meet physical activity guidelines in the last week and those who reported no alcohol consumption in the last week were also significantly less likely to report ever-screening and screening in the last two years (Table 2). Men who reported eating 5 or more serves of vegetables per day were significantly less likely to report ever-screening for CRC, but not screening in the last two years. Women who reported consuming 14 or more standard drinks of alcohol in the last week were significantly less likely to have ever-screened for CRC (Table 3). Physical activity and vegetable intake were not significantly associated with CRC screening participation for women (Table 3), and fruit intake and body mass index were not associated with CRC screening for either men or women (Tables 2 and 3).

**Table 2**
Colorectal cancer screening (ever and within the last two years) among men living in Australia 2014–15, by lifestyle characteristics and healthy lifestyle index (weighted data).

| | Total number eligible[a] | % screened in last 2 years | aRR (95% CI) | % ever screened | aRR (95% CI) |
|---|---|---|---|---|---|
| Smoking status | | | | | |
| Former/never | 3,112,120 | 35.5 | 1.00 | 56.9 | 1.00 |
| Current | 513,176 | 21.8 | 0.62 (0.47–0.83) | 42.2 | 0.85 (0.72–1.01) |
| Physical activity[b] | | | | | |
| Met guidelines | 501,336 | 41.0 | 1.00 | 64.7 | 1.00 |
| Did not meet guidelines | 3,123,960 | 32.4 | 0.80 (0.67–0.96) | 53.3 | 0.87 (0.78–0.97) |
| Alcohol consumption in last week | | | | | |
| ≤14 standard drinks | 1,410,539 | 34.5 | 1.00 | 57.2 | 1.00 |
| > 14 standard drinks | 986,952 | 37.4 | 1.04 (0.90–1.21) | 58.5 | 0.97 (0.89–1.07) |
| Did not drink | 234,303 | 21.0 | 0.71 (0.51–0.99) | 36.0 | 0.73 (0.59–0.91) |
| Vegetable consumption | | | | | |
| < 5 serves/day | 3,260,453 | 33.4 | 1.00 | 55.0 | 1.00 |
| ≥5 serves/day | 364,843 | 34.9 | 0.84 (0.65–1.10) | 53.8 | 0.84 (0.72–0.99) |
| Fruit consumption | | | | | |
| < 2 serves/day | 1,861,654 | 30.2 | 1.00 | 50.9 | 1.00 |
| ≥2 serves/day | 1,763,642 | 37.2 | 1.14 (0.99–1.32) | 59.1 | 1.08 (0.98–1.18) |
| Body mass index (kg/m$^2$) | | | | | |
| Not overweight (< 25) | 740,385 | 30.6 | 1.00 | 50.2 | 1.00 |
| Overweight (25 < 30) | 1,623,401 | 32.9 | 1.07 (0.87–1.31) | 54.1 | 1.04 (0.92–1.18) |
| Obese (≥30) | 1,261,510 | 36.1 | 1.17 (0.95–1.45) | 58.5 | 1.12 (0.98–1.27) |
| Healthy lifestyle index score | | | | | |
| 0–1 (least healthy) | 595,549 | 31.6 | 1.00 | 53.6 | 1.00 |
| 2 | 1,215,663 | 30.9 | 1.00 (0.82–1.23) | 51.2 | 0.97 (0.86–1.09) |
| 3 | 1,201,659 | 34.6 | 1.13 (0.93–1.37) | 56.3 | 1.05 (0.93–1.18) |
| 4–6 (most healthy) | 612,424 | 38.8 | 1.28 (1.03–1.59) | 60.6 | 1.10 (0.97–1.25) |
| *p for trend* | | | .005 | | .027 |

Models adjusted for age, highest level of education, country of birth, language spoken at home, area of residence, income, GP visits, private health insurance, ever diagnosis of cancer, participation in other cancer screening, regular performance of skin checks, smoking status, physical activity, alcohol consumption, fruit and vegetable consumption, body mass index.

[a] Extrapolated to Australian population using survey weights derived by Australian Bureau of Statistics.

[b] Whether physical activity in last week met Australia's Physical Activity and Sedentary Behaviour guidelines (reference - http://www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-phys-act-guidelines).

When lifestyle behaviours were considered together in a healthy lifestyle index, men and women reporting the most healthy behaviours were significantly more likely to have screened for CRC in the last two years (Tables 2 and 3). A significant trend for men was also observed for both CRC screening in the last two years and ever-screening, with the likelihood of screening increasing with increased numbers of healthy behaviours. For women, a significant trend was observed for ever-screening only, with likelihood of ever-screening for CRC increasing with increased number of healthy behaviours (Table 3). Our sensitivity analysis excluding fruit and vegetable consumption from the healthy lifestyle index found comparable results (results not presented).

Occupational variables were not significantly associated with participation in CRC screening for either men or women (Table 4). Similarly, no differences were found by shift work status.

## 4. Discussion

This is the first comprehensive assessment of the lifestyle and occupational factors associated with participation in CRC screening among men and women living in Australia. We found that 34% of men and 26% of women aged 50 and over reported screening for CRC in the past two years, slightly lower than the participation rate reported by the NBCSP for the same period (35% of men and 40% of women; Australian Institute of Health and Welfare, 2016). Participation was higher in those born in Australia, speaking English as their main language, reporting a higher income, and having private health insurance, as well as among those with a personal history of cancer. Those who participated in other forms of cancer screening, including skin cancer checks, also had higher CRC screening participation rates. These findings are similar to those reported in previous Australian studies (He et al., 2018; Varlow et al., 2014; Weber et al., 2008).

We also found participation in CRC screening to be associated with smoking, with current smokers less likely to report screening, in line with past research (Blanks et al., 2015; He et al., 2018; Shapiro et al., 2001). Men who were less physically active and had not consumed alcohol in the last week were also less likely to report screening for CRC, while women who reported drinking more alcohol were less likely than those drinking lower amounts of alcohol to report ever-screening for CRC. A previous Australian study also found that lower levels of physical activity and non-drinking were associated with lower CRC screening participation rates, although that study did not differentiate by gender (He et al., 2018). Our findings for women are in contrast to previous findings; however, it should be noted that women who did not consume alcohol in the past week had the lowest rates of participation in CRC screening, albeit not significant.

We also found that both men and women who reported engaging in more healthy behaviours were more likely to have ever-screened for CRC compared to those who reported no or one behaviour. Interestingly, these behaviours were not consistently associated with participation in CRC screening when considered in isolation. This suggests that the combination of behaviours an individual engages in, or their pattern of lifestyle behaviours, may be more important to consider when investigating participation in cancer screening, rather than examining the behaviours in isolation. The importance of considering combinations of lifestyle factors has also been demonstrated in association with CRC risk and survival, where those participating in more healthy behaviours have been found to have a lower risk of CRC (Aleksandrova et al., 2014) and longer survival after diagnosis (Van Blarigan et al., 2018).

We did not find participation in CRC screening to be associated with occupational variables in the present study. This is in contrast to a previous Australian study which found employment status to be associated with participation in CRC screening (Weber et al., 2013). This discrepancy could be due to the different categorisation of employment

**Table 3**
Colorectal cancer screening (ever and within the last two years) among women living in Australia 2014–15, by lifestyle characteristics and healthy lifestyle index (weighted data).

| | Total number eligible[a] | % screened in last 2 years | aRR (95% CI) | % ever screened | aRR (95% CI) |
|---|---|---|---|---|---|
| Smoking status | | | | | |
| Former/never | 3,454,974 | 27.3 | 1.00 | 50.8 | 1.00 |
| Current | 411,079 | 15.7 | 0.67 (0.48–0.94) | 34.4 | 0.78 (0.64–0.96) |
| Physical activity[b] | | | | | |
| Met guidelines | 546,979 | 32.5 | 1.00 | 57.4 | 1.00 |
| Did not meet guidelines | 3,319,074 | 25.0 | 0.90 (0.73–1.11) | 47.7 | 0.98 (0.86–1.10) |
| Alcohol consumption in last week | | | | | |
| ≤14 standard drinks | 1,522,129 | 30.7 | 1.00 | 55.7 | 1.00 |
| > 14 standard drinks | 401,463 | 28.9 | 0.93 (0.75–1.16) | 50.9 | 0.86 (0.76–0.99) |
| Did not drink | 690,735 | 22.0 | 0.90 (0.72–1.13) | 42.2 | 0.95 (0.84–1.08) |
| Vegetable consumption | | | | | |
| < 5 serves/day | 3,424,804 | 25.8 | 1.00 | 48.3 | 1.00 |
| ≥5 serves/day | 441,249 | 28.3 | 0.92 (0.73–1.17) | 55.2 | 1.04 (0.92–1.18) |
| Fruit consumption | | | | | |
| < 2 serves/day | 1,466,756 | 25.2 | 1.00 | 44.7 | 1.00 |
| ≥2 serves/day | 2,399,297 | 26.7 | 0.97 (0.82–1.15) | 51.7 | 1.04 (0.95–1.15) |
| Body mass index (kg/m$^2$) | | | | | |
| Not overweight (< 25) | 1,292,651 | 25.7 | 1.00 | 49.0 | 1.00 |
| Overweight (25 < 30) | 1,304,758 | 28.4 | 1.05 (0.87–1.26) | 50.9 | 1.09 (0.98–1.22) |
| Obese (≥30) | 1,268,645 | 24.2 | 0.84 (0.68–1.03) | 47.3 | 0.91 (0.81–1.03) |
| Healthy lifestyle index score | | | | | |
| 0–1 (least healthy) | 223,808 | 18.8 | 1.00 | 36.4 | 1.00 |
| 2 | 952,301 | 23.8 | 1.24 (0.87–1.78) | 45.5 | 1.25 (1.00–1.56) |
| 3 | 1,576,180 | 26.8 | 1.37 (0.97–1.92) | 49.2 | 1.32 (1.07–1.64) |
| 4–6 (most healthy) | 1,113,764 | 28.5 | 1.42 (1.00–2.01) | 54.6 | 1.42 (1.15–1.77) |
| *p for trend* | | | .075 | | < .001 |

Models adjusted for age, highest level of education, country of birth, language spoken at home, area of residence, income, GP visits, private health insurance, ever diagnosis of cancer, participation in other cancer screening, regular performance of skin checks, smoking status, physical activity, alcohol consumption, fruit and vegetable consumption, body mass index.

[a] Extrapolated to Australian population using survey weights derived by Australian Bureau of Statistics.

[b] Whether physical activity in last week met Australia's Physical Activity and Sedentary Behaviour guidelines (reference - http://www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-phys-act-guidelines).

status used; while our study used three categories (employed, unemployed, not in labour force), the previous study separated employment status into 10 different categories with significant associations found in only some of these categories. Specifically, Weber and colleagues found that men in part-time work or who were partially or fully retired were more likely to have participated in CRC screening, while women who were self-employed, in unpaid or part-time work, partially or fully retired, looking after the home, or sick or disabled were more likely to have participated than those in full-time work (Weber et al., 2013). Our data did not have this level of detail; our use of three categories may have meant that some of these differences were not able to be detected.

Studies in other countries have also found that those working shift work were less likely to participate in CRC screening (Nicholls et al., 2017; Tsai et al., 2014); however, we did not find any association between shift work status and CRC screening participation. This may be due in part to the definition of shift work, which in the current study was self-defined and limited to work in the past four weeks. Past research has included a longer time period (12 months, ever) and based the definition of shift work on reported hours worked. However, a study investigating the association between shift work and participation in breast cancer screening also found no difference in participation by shift work status (Son and Kang, 2017). These conflicting results suggest that more research is needed to clarify the relationship between shift work and cancer screening participation.

### 4.1. Study limitations and strengths

This study has some limitations that should be noted. Firstly, this study was based on cross-sectional data, making it difficult to determine the direction of association between lifestyle and occupational factors and CRC screening participation. In addition, CRC screening participation was self-reported, which may introduce possible social desirability and recall biases. However, previous studies have found self-reported history of screening participation to be reliable and to have high levels of agreement with medical records (Baier et al., 2000; Khoja et al., 2007), although other studies have found that participants tend to over-report CRC screening participation (Lofters et al., 2015; Shokar et al., 2011). Given that we found lower levels of reported participation than that reported by the NBCSP (Australian Institute of Health and Welfare, 2018b), over-reporting is unlikely. We were also unable to include all lifestyle factors which have been associated with CRC risk (in particular, red and processed meat, dietary fibre) as these behaviours were not collected in the National Health Survey. However, past research has found no association between CRC screening participation and these dietary behaviours (He et al., 2018). Some strengths to this study should also be noted. We used data from a large national survey which is representative of the Australian population and had a response rate of 82% (Australian Bureau of Statistics, 2015). This comprehensive data allowed us to assess a number of variables as potential confounders.

## 5. Conclusions

In conclusion, we found that participation in CRC screening was lower among those born overseas, speaking a foreign language, reporting a lower income, and not having private health insurance. Those who did not participate in other forms of cancer screening, including performing skin checks, also reported lower participation. With regard to lifestyle behaviours, few associations were found between individual behaviours and CRC screening participation. However, higher participation rates were observed in those reporting a higher number of healthy behaviours for both men and women. No associations were observed between occupational variables and CRC screening

**Table 4**
Colorectal cancer screening (ever and within the last two years), by occupational characteristics (weighted data).

| | Total number eligible[a] | Screening within the last 2 years | | Ever screening | |
|---|---|---|---|---|---|
| | | % screened | aRR (95% CI) | % screened | aRR (95% CI) |
| *Men* | | | | | |
| Labour force status | | | | | |
| Employed | 1,842,462 | 35.3 | 1.00 | 53.0 | 1.00 |
| Unemployed | 75,246 | 25.1 | 0.80 (0.47–1.37) | 42.0 | 0.89 (0.63–1.25) |
| Not in labour force | 1,707,588 | 32.0 | 0.99 (0.84–1.18) | 57.4 | 1.07 (0.96–1.19) |
| Occupation[b] | | | | | |
| Manager | 419,931 | 35.3 | 1.00 | 55.1 | 1.00 |
| Professional | 389,044 | 35.5 | 1.03 (0.79–1.35) | 57.8 | 1.07 (0.90–1.28) |
| Technician/trades | 312,315 | 36.3 | 1.14 (0.86–1.51) | 54.2 | 1.07 (0.89–1.30) |
| Community/service | 94,893 | 27.6 | 0.94 (0.57–1.55) | 44.4 | 0.95 (0.67–1.33) |
| Clerical/administrative | 128,119 | 35.2 | 1.12 (0.78–1.61) | 53.3 | 1.08 (0.85–1.37) |
| Sales | 71,393 | 38.6 | 1.20 (0.80–1.80) | 51.0 | 0.99 (0.73–1.35) |
| Machinery operator | 242,547 | 34.2 | 1.12 (0.80–1.55) | 47.5 | 0.95 (0.76–1.20) |
| Labourer | 180,386 | 37.4 | 1.24 (0.90–1.71) | 47.8 | 0.98 (0.77–1.25) |
| Shift work[c] | | | | | |
| No | 1,564,747 | 35.0 | 1.00 | 52.7 | 1.00 |
| Yes | 277,715 | 37.0 | 1.09 (0.85–1.39) | 55.2 | 1.11 (0.94–1.30) |
| Night shift[d] | | | | | |
| No | 214,365 | 36.2 | 1.00 | 53.0 | 1.00 |
| Yes | 63,350 | 39.9 | 1.28 (0.78–2.10) | 62.4 | 1.29 (0.93–1.79) |
| *Women* | | | | | |
| Labour force status | | | | | |
| Employed | 1,517,819 | 30.6 | 1.00 | 52.5 | 1.00 |
| Unemployed | 53,414 | 19.2 | 0.70 (0.35–1.38) | 37.7 | 0.80 (0.52–1.24) |
| Not in labour force | 2,294,820 | 23.3 | 0.87 (0.73–1.05) | 47.1 | 0.98 (0.89–1.09) |
| Occupation[b] | | | | | |
| Manager | 169,867 | 29.3 | 1.00 | 55.9 | 1.00 |
| Professional | 391,737 | 33.9 | 1.14 (0.79–1.65) | 54.1 | 0.97 (0.78–1.20) |
| Technician/trades | 53,542 | 23.4 | 0.90 (0.46–1.75) | 48.9 | 0.99 (0.69–1.42) |
| Community/service | 217,253 | 31.0 | 1.06 (0.70–1.60) | 49.3 | 0.92 (0.72–1.19) |
| Clerical/administrative | 381,907 | 32.4 | 1.15 (0.80–1.65) | 56.9 | 1.05 (0.85–1.29) |
| Sales | 131,314 | 30.9 | 1.11 (0.71–1.74) | 56.6 | 1.03 (0.85–1.34) |
| Machinery operator | 25,348 | 29.2 | 1.16 (0.54–2.53) | 40.2 | 0.82 (0.46–1.46) |
| Labourer | 146,851.5 | 20.8 | 0.74 (0.42–1.31) | 37.2 | 0.75 (0.53–1.06) |
| Shift work[c] | | | | | |
| No | 1,292,565 | 30.8 | 1.00 | 53.0 | 1.00 |
| Yes | 225,254 | 29.4 | 1.01 (0.75–1.35) | 49.6 | 1.02 (0.85–1.22) |
| Night shift[d] | | | | | |
| No | 169,834 | 30.8 | 1.00 | 53.2 | 1.00 |
| Yes | 55,420 | 25.2 | 0.85 (0.42–1.75) | 38.7 | 0.83 (0.49–1.41) |

Models adjusted for age, highest level of education, country of birth, language spoken at home, area of residence, income, GP visits, private health insurance, ever diagnosis of cancer, participation in other cancer screening, and regular performance of skin checks.

[a] Extrapolated to Australian population using survey weights derived by Australian Bureau of Statistics.

[b] According to Australian and New Zealand Standard Classification of Occupations (ANZSCO); includes only those employed (n = 1,842,462 men; 1,517,819 women).

[c] Whether did shift work in the last four weeks; includes only those employed (n = 1,842,462 men; 1,517,819 women).

[d] Whether shift work pattern in last four weeks included "regular evening, night or graveyard shift"; includes only those doing shift work (n = 277,715 men; 225,254 women).

participation. These findings have important implications for public health strategies on how to improve CRC screening participation, providing information about the groups who are least likely to screen. Identifying factors associated with CRC screening participation can assist health professionals, including general practitioners, to identify those who are less likely to participate in screening, and accordingly to encourage those individuals to undergo CRC screening.

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