

## ORIGINAL ARTICLE

# Post-traumatic stress disorder is associated with a higher rate of polypectomy independent of an increased frequency of colonoscopy in Australian veterans: a retrospective review

Darrell H. G. Crawford <sup>1,2</sup>, Rebecca Mellor <sup>1</sup>, Andrew Teo <sup>1</sup>, Patrick Duenow<sup>3</sup> and Luke B. Connelly <sup>3,4</sup>

<sup>1</sup>Gallipoli Medical Research Foundation, Greenslopes Private Hospital, and <sup>2</sup>Faculty of Medicine, and <sup>3</sup>Centre for the Business and Economics of Health, The University of Queensland, Brisbane, Queensland, Australia, and <sup>4</sup>Department of Sociology and Business Law, The University of Bologna, Bologna, Italy

## Key words

post-traumatic stress disorder, veterans, colonoscopy, polypectomy.

## Correspondence

Darrell H. G. Crawford, Gallipoli Medical Research Foundation, Greenslopes Private Hospital, Newdegate Street, Greenslopes, Brisbane, Qld, Australia.  
Email: [d.crawford@uq.edu.au](mailto:d.crawford@uq.edu.au)

Received 10 March 2022; accepted 5 May 2022.

## Abstract

**Background:** Post-traumatic stress disorder (PTSD) is associated with extensive physical comorbidities, including lower gastrointestinal symptoms. Diagnostic uncertainty and poor therapeutic responses may result in more frequent colonoscopies than clinically necessary. Polypectomy is standard practice when polyps are identified, and if PTSD is a risk factor for polyp formation, one would expect a higher rate of polyp detection and removal in veterans with PTSD than those without PTSD.

**Aim:** To determine the association between PTSD and the rate of colonoscopy and polypectomy in Australian veterans.

**Methods:** Diagnostic and therapeutic colonoscopy rates in Australian male Veterans aged  $\geq 50$  years were examined by reviewing case records of veterans who accessed Department of Veterans' Affairs funded health services between 1 January 2013 and 31 December 2018.

**Results:** A total of 138 471 veterans was included, of whom 28 018 had a diagnosis of PTSD; 56.4% were aged  $\geq 65$  years. Twenty-one percent of the entire cohort underwent at least one colonoscopy during the study period. Increased rates of diagnostic colonoscopy and polypectomy were associated with the presence of PTSD across all age brackets. The effect was empirically large as veterans with PTSD experience colonoscopy rates 76–81% greater than those without PTSD. Similarly, veterans with PTSD experienced polypectomy rates 76–81% greater than veterans without PTSD, and this increase persisted when controlling for the increased number of diagnostic colonoscopies they undergo.

**Conclusion:** The presence of PTSD has a marked impact on colonoscopy rates in Australian veterans. The increased polypectomy rate independent of increased colonoscopy rate suggests that PTSD is a risk factor for colonic polyp formation.

## Introduction

Post-traumatic stress disorder (PTSD) is a disabling mental health condition that can develop following exposure to a traumatic event. The lifetime prevalence of PTSD in Australian veterans has been reported to be 16.5–20.9%.<sup>1</sup> As well as being characterised by significant psychological effects, PTSD is associated with

extensive physical comorbidities. Veterans with PTSD are more likely to suffer physical illness and chronic disease than the general population, and veterans without PTSD.<sup>2,3</sup> Diseases of the cardiovascular, respiratory and gastrointestinal systems are 2–8 times more frequent in Vietnam ex-service personnel with PTSD than veterans without PTSD.<sup>4</sup> Specific to the gastrointestinal system, there is a significantly higher prevalence of gastroesophageal reflux, peptic ulcer disease, irritable bowel syndrome and fatty liver disease in veterans with PTSD.

Funding: Gallipoli Medical Research Foundation.

Conflict of interest: None.

Treatment of gastrointestinal symptoms in PTSD can be difficult, and ongoing symptoms can generate uncertainty about the cause and management of the condition, and concern about a missed or alternative diagnosis. These concerns may also result in more endoscopic investigations than is clinically necessary. Studies<sup>2,5–7</sup> have found that Vietnam veterans diagnosed with PTSD reported significantly more healthcare utilisation, and that a diagnosis of PTSD is associated with medical costs 60% greater than average.<sup>8</sup>

The veteran population has a higher prevalence of colorectal cancer and adenoma than the general population and this has been explained by risk factors, such as predominance of male sex and high rates of cigarette use.<sup>9</sup> In a limited number of studies to date, PTSD has not been reported to be a risk factor for colon cancer.<sup>10</sup> Most cancers of the colon and rectum evolve from adenomatous polyps and villous adenomas.<sup>11</sup> Polypectomy is standard practice when polyps are identified at colonoscopy, and it is recognised that endoscopic screening with polypectomy and appropriate follow up reduces the incidence and mortality of colorectal cancer<sup>9,12</sup>. Thus, if PTSD was a risk factor for colonic polyps and colon cancer, one would expect a higher rate of polyp detection and removal in veterans with PTSD than those without PTSD.

Therefore, in this study, the impact of PTSD on the utilisation of gastrointestinal investigations, and if PTSD *per se* is an independent risk factor for polypectomy (and by inference, polyp formation) was assessed in a large cohort of Australian male veterans.

## Methods

The study was approved by the Departments of Defence and Veterans' Affairs Human Research Ethics Committee, Canberra, Australia (DDVA HREC/OUT/2019/BN10068239).

### Study population

The Department of Veterans' Affairs (DVA) is a department of the Australian Government that provides support and services for the veteran population, including pathways and funding of care. The case records of male ex-service personnel over the age of 50 years at 1 January 2013 who accessed health services funded by DVA in the period 1 January 2013 until 31 December 2018 were reviewed. The presence or absence of comorbid PTSD at commencement of the study was noted. The number of complete diagnostic and therapeutic colonoscopies to evaluate the lower gastrointestinal tract were recorded according to the Medical Benefits

Schedule (MBS) item numbers 32090 and 32093. During the data collection period, the MBS schedule defined a procedure item number 32090 as 'Fibreoptic colonoscopy examination of the colon beyond the hepatic flexure with or without biopsy', and 32093 as 'Endoscopic examination of the colon beyond the hepatic flexure by fibreoptic colonoscopy for the removal of one or more polyps, or the treatment of radiation proctitis, angiodysplasia or post-polypectomy bleeding by argon plasma coagulation'. In practice, virtually all 32093 billings relate to colonoscopic polypectomy (these item numbers have since been revised). Additionally, the presence of other reported medical conditions of anxiety, depression, diabetes, alcohol dependence, obesity and respiratory disorders was noted. The number of diagnostic and therapeutic colonoscopy procedures conducted on each patient was determined by linking the participant's DVA number with the relevant item numbers. Participants were not included in the analysis if data were missing or unavailable for any of the variables described above.

### Statistical analysis

To address the aims of the present study, we regressed the number of investigations, disaggregated by type, on a binary PTSD diagnosis variable (= 1 if present; = 0 otherwise). Controls included a series of binary variables that represent the patient's 5-year age category (age 50–54 years through to age 75+ years, with age 50–54 years as the reference category) as well as any coexistence of anxiety, depression, diabetes, alcohol dependence, obesity, and respiratory problems. In addition, we constructed a simple Charlson-type index that is a count of the number of other conditions (excluding those included as controls, e.g. anxiety, depression, diabetes) that is present for a given patient. We also tested for further non-linearities through the inclusion of a quadratic term on the number of present conditions. The dependent variable employed in this case was the number of colonoscopies performed. Specifically, we modelled the total numbers of colonoscopies billed on the Australian Medicare Benefits Schedule for diagnostic colonoscopy (Item 32090) and for therapeutic colonoscopy (Item 32093) as well as the total of these two procedures per patient. The specifications of the three models were identical with one important exception: the model for therapeutic colonoscopy controls for the number of diagnostic colonoscopies as we hypothesise that these two procedures are positively correlated.

The dependent variables employed in this study are 'count' variables as they consist of non-negative integers. The negative binomial (NB) model was chosen as

**Table 1** Number and percentage of participants in each age category for the total cohort of participants, and for those with and without post-traumatic stress disorder (PTSD)

Age category (years)†	Total cohort, <i>n</i> (%)	PTSD, <i>n</i> (%)	Without PTSD, <i>n</i> (%)
50–54	13 819 (10)	607 (2.2)	13 212 (12)
55–59	12 103 (11)	718 (2.6)	12 103 (11)
60–64	24 035 (17.4)	7543 (26.9)	16 492 (14.9)
65–69	27 369 (19.8)	12 505 (44.6)	14 864 (13.5)
70–75	9694 (7)	2422 (8.6)	7272 (6.6)
75+	50 727 (36.6)	4223 (15.1)	46 504 (42.1)

†With available age category data.

**Table 2** Number of patients and number of procedures (colonoscopies ± polypectomies), in increasing numerical categories, described for the total cohort and for those with and without PTSD

	Total cohort, <i>n</i> (%)	PTSD, <i>n</i> (%)	Without PTSD, <i>n</i> (%)
Number of colonoscopies ± polypectomies	<i>n</i> = 138 471	<i>n</i> = 28 018	<i>n</i> = 110 453
0	109 053 (78.7)	15 689 (55.9)	93 364 (84.5)
1–3	28 603 (20.7)	11 943 (42.6)	16 660 (15.1)
4–6	795 (0.005)	374 (1.3)	421 (0.4)
7–9	18	11	7
10+	2	1	1

our preferred specification, as a result of overdispersion of the dependent variables. For ease of interpretation, the results obtained from the estimated NB models are presented as incident-rate ratios (IRR). The reported IRR represent the estimated change in the rate of the dependent variable for a one-unit change in the covariate in question. The estimated IRR for a binary explanatory variable represents the rate at which the incident rate of the dependent variable is affected by the presence of a characteristic, compared with that which occurs in its absence.

## Results

### Demographics

The total number of patients in the cohort was 138 471. Of these, 28 018 had a diagnosis of PTSD, while 110 453 did not have a diagnosis of PTSD. All patients were male, and most patients were in the 75+ age category (36.6% of the total cohort). The next most common age category was 65–69 years (19.8% of the cohort). Table 1 outlines the number and percentage of patients in each age category for the total cohort (*N* = 138 471), and for those with and without PTSD. Age data were missing for six individuals.

Of the total cohort examined, 29 418 (21.2%) had undergone at least one diagnostic colonoscopy and/or colonoscopic polypectomy. Procedures were more common in Veterans with PTSD than those without (12 329/28 018 (44%) vs 17 089/110 453 (15.5%)). Most (20.7%) patients in the cohort who had a procedure had

between one to three gastrointestinal procedures. In fact, 78 patients had greater than five procedures performed in the 5-year study period. Of those with PTSD, 42.6% had between one to three investigations, whereas, of those without PTSD, 15.1% had between one to three investigations. Of those with PTSD, 1.3% had between four to six colonoscopies with or without polypectomy, compared to 0.4% of those without PTSD. Table 2 outlines, in incremental categories, the number of procedures for the total cohort, and for those with and without PTSD.

Table 3 reports IRR estimated on three specifications of NB models of gastrointestinal investigations. The first noteworthy point is that, with the exception of the binary indicator of obesity, all of the IRR estimates are statistically significant.

Furthermore, with the exceptions of obesity and the quadratic term for the Charlson index, all IRR are greater than unity. These results indicate that gastrointestinal investigations are increasing functions of age (except for the oldest age group, in which the number is no longer increasing) and the presence of comorbidities.<sup>a</sup> Note that the magnitudes of the IRR estimates are similar

<sup>a</sup> Note that the IRR on the linear term in the Charlson index is greater than one and that the quadratic term is fairly close to 1.00. Together, these estimates are to be interpreted as indicating that, other things equal, the number of investigations increases with the Charlson index, but that the rate of increase declines as the Charlson index rises.

**Table 3** The effect of PTSD and comorbidities on gastrointestinal investigations among Australian Vietnam veterans: Incident rate ratios (IRR) from negative binomial models

Variables	Total (polypectomies + colonoscopies)	Polypectomies	Diagnostic colonoscopies
PTSD diagnosis	1.811*** (1.76–1.86)	1.785*** (1.72–1.85)	1.758*** (1.69–1.83)
Age 55–59 years	1.725*** (1.58–1.88)	1.886*** (1.68–2.11)	1.540*** (1.37–1.73)
Age 60–64 years	3.524*** (3.27–3.79)	4.044*** (3.67–4.46)	2.878*** (2.61–3.18)
Age 65–69 years	4.956*** (4.61–5.33)	5.529*** (5.02–6.09)	4.048*** (3.69–4.47)
Age 70–74 years	5.807*** (5.37–6.27)	6.841*** (6.18–7.57)	4.279*** (3.85–4.75)
Age 75+ years	1.992*** (1.85–2.15)	2.082*** (1.88–2.29)	1.815*** (1.64–2.00)
Anxiety	1.312*** (1.27–1.36)	1.306*** (1.25–1.37)	1.289*** (1.23–1.35)
Depression	1.444*** (1.39–1.49)	1.361*** (1.29–1.43)	1.480*** (1.41–1.55)
Diabetes	1.178*** (1.10–1.25)	1.208*** (1.11–1.31)	1.113** (1.02–1.22)
Alcohol dependency	1.191*** (1.15–1.23)	1.262*** (1.29–1.43)	1.079*** (1.03–1.13)
Respiratory illness	1.070*** (1.02–1.12)	1.154*** (1.08–1.23)	0.961 (0.89–1.03)
Obesity	1.061 (0.82–1.37)	0.947 (0.67–1.34)	1.202 (0.80–1.80)
Charlson Index	1.129*** (1.12–1.14)	1.111*** (1.09–1.12)	1.146*** (1.13–1.16)
Charlson Index Squared	0.997*** (0.996–0.997)	0.997*** (0.996–0.998)	0.996*** (0.995–0.997)
No. diagnostic colonoscopies		1.342*** (1.29–1.38)	
Constant	0.0547*** (0.05–0.06)	0.0280*** (0.02–0.03)	0.0273*** (0.02–0.03)
Alpha	1.062*** (1.02–1.11)	1.802*** (1.72–1.88)	1.098*** (1.02–1.18)
Observations	138 465	138 465	138 465

Data in parentheses are 95% confidence intervals; \*\*\* $P < 0.01$ ; \*\* $P < 0.05$ ; \* $P < 0.1$ .

across specifications. As expected, colonoscopies are positively associated with increases in the number of polypectomies in the specification for which the latter is the dependent variable.

The IRR of primary interest are reported in Table 3, on the effect of PTSD. Note that all three estimated IRR are statistically significant and are substantially larger than unity. This suggests that PTSD is associated with more gastrointestinal investigations overall, as well as with both more colonoscopies and more polypectomies, *ceteris paribus*. Moreover, the effect is empirically large: the IRR on this variable (PTSD) are between approximately 1.76 and 1.81, indicating that veterans with PTSD experience colonoscopy rates that are 76–81% greater than those of their colleagues without diagnosed PTSD.

Aside from the large magnitudes of the binary variables on age – indicating that more investigations are correlated with advancing age – the IRR on diagnoses of both anxiety and depression are also sizeable. This indicates that those comorbidities are correlated with increased rates of use of these items of between approximately 30% and 40%.

## Discussion

PTSD is characterised by a high frequency of physical comorbidities, including numerous conditions of the gastrointestinal tract. This study quantified the impact of PTSD on diagnostic and therapeutic colonoscopy rates in a large cohort of Australian male veterans over the age of 50 years. Forty-four percent of veterans with PTSD

underwent at least one diagnostic colonoscopy or polypectomy over the 5-year study period, whereas only 15.5% of veterans without PTSD underwent at least one of these procedures. Patients with PTSD were approximately 76–81% more likely to undergo colonoscopy and the presence of PTSD was the strongest individual predictor of greater use of these procedures.

The persisting nature and poor response of gastrointestinal symptoms to treatment, limited awareness of the association between PTSD and gut symptoms, and physician and patient concerns regarding ‘missed’ diagnoses are likely to underpin the increased investigations in affected patients. Recently the Australian Commission of Safety and Quality in HealthCare developed colonoscopy clinical care standards,<sup>13</sup> which reflects Cancer Council Australia guidelines for screening and surveillance in colonoscopy.<sup>14</sup> Implementation of these guidelines that are based on the best available clinical evidence and their alignment with reimbursement purposes is likely to increase clinician and patient confidence in timing for colonoscopy and reduce the burden of unnecessary procedures for patients with PTSD, as well as for the broader community.

In 2016–2017, 800 000 colonoscopies were conducted in Australia – or one colonoscopy for every 32 Australians.<sup>15</sup> By comparison, in this veteran population of 138 471 individuals, 45 463 of these procedures were performed over a 5-year period – or one colonoscopy/polypectomy for every 3.04 veterans. When PTSD-affected patients were considered, 19 616 colonoscopies/polypectomies were performed in 28 018 individuals – or one colonoscopy for every 1.4 veterans with PTSD.

The rate of colonoscopy within a population is strongly influenced by age, and the colonoscopy utilisation rate in the general population for patients over the age of 50 years is greatest in the 65–69-year age bracket with a utilisation rate of approximately 60 per 1000 population.<sup>16</sup> Utilisation rates in this veteran population were much higher, being 329 per 1000 overall and increasing to 704 per 1000 for PTSD patients. Thus, in addition to age and geographical location, veteran status and the presence of PTSD strongly influence the rate of colonoscopy in the Australian community.

Of major interest is our finding that rates of polypectomy were higher in patients with PTSD compared to those without PTSD. Colonic polyps are precursors of colorectal cancer and polypectomy reduces the risk of colon cancer and is standard practice once colonic polyps are detected. This observation raises the possibility that PTSD *per se* could be a risk factor for colonic polyp formation and colorectal cancer. At present, PTSD is not known to be a risk factor for colon cancer,<sup>10</sup> but studies are limited in this field. There are plausible reasons for an increased prevalence of colorectal cancer in PTSD. The presence of PTSD is associated with higher rates of obesity, alcohol use and cigarette use than in veterans without PTSD<sup>17,18</sup> and there is strong evidence that these modifiable lifestyle factors play a key role in colorectal carcinogenesis.<sup>19,20</sup> Epidemiologic data have consistently reported a positive association between obesity and colorectal cancer,<sup>21</sup> and numerous meta-analyses in Western populations have linked cigarette smoking and alcohol consumption to 30–40% increased colorectal cancer risk.<sup>22–24</sup>

This study investigated a large database of Veteran's health but there are associated limitations. The histology of the polyps was not contained in the database – we suggest that histological analysis needs to be conducted in future studies. The study population was limited to male veterans only – principally because there are so few women veterans in the age group under study. It would be of interest to determine if the same outcomes are found in women. The database did not allow interrogation of a veteran's access to endoscopic services that may have influenced uptake and frequency of colonoscopy in some individuals. It is also important to note that this study was restricted to veterans entitled to DVA funded services for all health conditions whether they are related to military service or not. In addition, we did not consider survival in the dataset, as we implicitly assumed that the

individuals were observed over the course of the 5-year study period. However, if veterans with and without PTSD have a similar life expectancy over this period, this would only increase the robustness of our results.

## Conclusion

In summary, this study has shown that the presence of PTSD is a major determinant of utilising colonoscopy services in Australian male veterans, indicating that those with PTSD are 76–81% more likely to undergo this procedure than those without PTSD. This may reflect the persisting nature and poor response to treatment of gut symptoms that often occur in patients with PTSD or, in part, limited physician awareness of the association between PTSD and gut symptoms. More physician and patient-centred education on clinical manifestations of PTSD is warranted to reduce unnecessary investigations. The increased rate of polypectomy independent of the increased number of colonoscopies in PTSD patients suggests that PTSD *per se* may be a risk factor for colonic polyps, and potentially colorectal cancer and this possible association requires further study.

## Acknowledgements

This journal article has been produced using data provided by the Australian Government Department of Veterans' Affairs. However, the views expressed do not necessarily represent the views of the Minister for Veterans' Affairs or the Department of Veterans' Affairs. The Commonwealth does not give any warranty nor accept any liability in relation to the contents of this work. Open access publishing facilitated by The University of Queensland, as part of the Wiley - The University of Queensland agreement via the Council of Australian University Librarians.

## Data availability statement

Data are not publicly available. It was released from the Australian Government Department of Veterans' Affairs for our research purposes after approval from the Department of Defence and Department of Veterans' Affairs Human Research Ethics Committee (DDVA HREC/OUT/2019/BN10068239).

## References

- O'Toole BI, Marshall RP, Grayson DA, Schureck RJ, Dobson M, French M *et al.* The Australian Vietnam Veterans Health Study: III. Psychological health of Australian Vietnam veterans and its relationship to combat. *Int J Epidemiol* 1996; **25**: 331–40.
- O'Toole BI, Catts SV. Trauma, PTSD, and physical health: an epidemiological study of Australian Vietnam veterans. *J Psychosom Res* 2008; **64**: 33–40.
- Boscarino JA. Posttraumatic stress disorder and physical illness: results from clinical and epidemiologic studies. *Ann N Y Acad Sci* 2004; **1032**: 141–53.
- McLeay SC, Harvey WM, Romaniuk MN, Crawford DH, Colquhoun DM, Young RM *et al.* Physical comorbidities of



- post-traumatic stress disorder in Australian Vietnam War veterans. *Med J Aust* 2017; **206**: 251–7.
- 5 Long N, Chamberlain K, Vincent C. The health and mental health of New Zealand Vietnam War veterans with posttraumatic stress disorder. *N Z Med J* 1992; **105**: 417–19.
  - 6 Marshall RP, Jorm AF, Grayson DA, O'Toole BI. Posttraumatic stress disorder and other predictors of health care consumption by Vietnam veterans. *Psychiatr Serv* 1998; **49**: 1609–11.
  - 7 Beckham JC, Moore SD, Feldman ME, Hertzberg MA, Kirby AC, Fairbank JA. Health status, somatization, and severity of posttraumatic stress disorder in Vietnam combat veterans with posttraumatic stress disorder. *Am J Psychiatry* 1998; **155**: 1565–9.
  - 8 Marshall RP, Jorm AF, Grayson DA, O'Toole BI. Medical-care costs associated with posttraumatic stress disorder in Vietnam veterans. *Aust N Z J Psychiatry* 2000; **34**: 954–62.
  - 9 Kahi CJ, Pohl H, Myers LJ, Mobarek D, Robertson DJ, Imperiale TF. Colonoscopy and colorectal cancer mortality in the veterans affairs health care system a case-control study. *Ann Intern Med* 2018; **168**: 481+.
  - 10 Gradus JL, Farkas DK, Svensson E, Ehrenstein V, Lash TL, Toft SH. Posttraumatic stress disorder and gastrointestinal disorders in the Danish population. *Epidemiology* 2017; **28**: 354–60.
  - 11 Morson B. Polyp-cancer sequence in large bowel. *P Roy Soc Med* 1974; **67**: 451–7.
  - 12 Brenner H, Stock C, Hoffmeister M. Effect of screening sigmoidoscopy and screening colonoscopy on colorectal cancer incidence and mortality: systematic review and meta-analysis of randomised controlled trials and observational studies. *BMJ* 2014; **348**: g2467.
  - 13 Australian Commission on Safety and Quality in Health Care. Colonoscopy Clinical Care Standard. Sydney. 2020. Available from URL: [www.safetyandquality.gov.au/our-work/clinical-care-standards/colonoscopy-clinical-care-standard](http://www.safetyandquality.gov.au/our-work/clinical-care-standards/colonoscopy-clinical-care-standard)
  - 14 Cancer Council Australia Surveillance Colonoscopy Guidelines Working Party. *Clinical Practice Guidelines for Surveillance Colonoscopy*. Sydney: Cancer Council Australia; 2018. Available from URL: <https://protect-au.mimecast.com/s/vf7CQnMgRS3P1qNtx1tVM?domain=wiki.cancer.org.au>
  - 15 Duggan A, Skinner IJ, Bhasale AL. All colonoscopies are not created equal: why Australia now has a clinical care standard for colonoscopy. *Med J Australia* 2018; **209**: 427–30.
  - 16 Australian Government Department of Health Care and Ageing. Review of MBS colonoscopy items: Australian Government; 2011. Available from URL: [https://www1.health.gov.au/internet/main/publishing.nsf/Content/Colonoscopy\\_Review](https://www1.health.gov.au/internet/main/publishing.nsf/Content/Colonoscopy_Review)
  - 17 Vieweg WV, Julius DA, Bates J, Quinn JF 3rd, Fernandez A, Hasnain M et al. Posttraumatic stress disorder as a risk factor for obesity among male military veterans. *Acta Psychiatr Scand* 2007; **116**: 483–7.
  - 18 Schnurr PP, Jankowski MK. Physical health and post-traumatic stress disorder: review and synthesis. *Semin Clin Neuropsychiatry* 1999; **4**: 295–304.
  - 19 Lieberman DA, Prindiville S, Weiss DG, Willett W, Group VACS. Risk factors for advanced colonic neoplasia and hyperplastic polyps in asymptomatic individuals. *JAMA* 2003; **290**: 2959–67.
  - 20 Siddiqui A, Pena Sahdala HN, Nazario HE, Mahgoub A, Patel M, Cipher D et al. Obesity is associated with an increased prevalence of advanced adenomatous colon polyps in a male veteran population. *Dig Dis Sci* 2009; **54**: 1560–4.
  - 21 Moghaddam AA, Woodward M, Huxley R. Obesity and risk of colorectal cancer: a meta-analysis of 31 studies with 70,000 events. *Cancer Epidemiol Biomarkers Prev* 2007; **16**: 2533–47.
  - 22 Longnecker MP, Orza MJ, Adams ME, Vioque J, Chalmers TC. A meta-analysis of alcoholic beverage consumption in relation to risk of colorectal cancer. *Cancer Causes Control* 1990; **1**: 59–68.
  - 23 Cho E, Smith-Warner SA, Ritz J, van den Brandt PA, Colditz GA, Folsom AR et al. Alcohol intake and colorectal cancer: a pooled analysis of 8 cohort studies. *Ann Intern Med* 2004; **140**: 603–13.
  - 24 Giovannucci E. An updated review of the epidemiological evidence that cigarette smoking increases risk of colorectal cancer. *Cancer Epidemiol Biomarkers Prev* 2001; **10**: 725–31.