Cancer Epidemiol Biomarkers Prev. Author manuscript; available in PMC 2014 February 21.

Published in final edited form as:

Cancer Epidemiol Biomarkers Prev. 2012 May ; 21(5): 737–746. doi:10.1158/1055-9965.EPI-11-0826.

Body Mass Index and Colon Cancer Screening: A Systematic Review and Meta-Analysis

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Abstract

Background—Obesity is associated with increased colon cancer mortality and lower rates of mammography and Pap testing.

Methods—We conducted a systematic review to determine if obesity is associated with lower rates of colon cancer screening. We searched the PubMed, CINAHL, and Cochrane Library databases. Two investigators reviewed citations, abstracts, and articles independently. Two investigators abstracted study information sequentially and evaluated quality independently using standardized forms. We included all studies in our qualitative syntheses. We used random effects meta-analyses to combine those studies providing screening results by the following BMI categories: Normal, 18.5–24.9 kg/m^2 (reference); overweight, 25–29.9 kg/m^2; class I obesity, 30–34.9 kg/m^2; class II obesity, 35–39.9 kg/m^2; and class III obesity, ≥ 40 kg/ m^2.

Results—Of 5,543 citations, we included 23 articles. Almost all studies were cross-sectional and ascertained BMI and screening through self report. BMI was not associated with colon cancer screening overall. The subgroup of obese white women reported lower rates of colon cancer screening compared to those with a normal BMI with combined odds ratios (95% CI) of 0.87 (0.82 to 0.93), 0.80 (0.65 to 0.99), and 0.73 (0.54 to 0.94) for class I, II, and III obesity, respectively. Results were similar among white men with class II obesity.

Conclusions—Overall, BMI was not associated with colon cancer screening. Obese white men and women may be less likely to undergo colon cancer screening compared to those with a normal BMI.

Impact—Further investigation of this disparity may reduce the risk of obesity-related colon cancer death.

Keywords

Colon cancer screening; obesity; meta-analysis; screening; prevention; disparity

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Disclosures: The authors have no conflicts of interest to disclose.

Prior presentation: Preliminary results presented at the 2009 Society of General Internal Medicine National Meeting (Miami).

Introduction

Colorectal cancer is the third leading cause of cancer death in the United States (1). While screening for colon cancer with fecal occult blood testing (FOBT), flexible sigmoidoscopy, or colonoscopy decreases colon cancer risk (2) and mortality and is recommended for all adults between the ages of 50 and 75 years (3), rates of colon cancer screening are suboptimal. In 2005, only 20% of women and 24% of men over the age of 50 years reported endoscopic screening, and only 12% of women and men reported FOBT in the United States (4). Identification of barriers to screening can inform public health approaches to increase colon cancer screening and thus reduce colon cancer deaths.

In previous systematic reviews and meta-analyses, we have shown that obese women, especially obese white women, are less likely to undergo breast and cervical cancer screening compared to their normal weight counterparts (5, 6). Colon cancer mortality increases with increasing body mass index (BMI) (7), but whether obese persons are less likely to receive screening for colon cancer is unclear.

Therefore, we conducted a systematic review to: 1) Evaluate the association between obesity and colon cancer screening and 2) Determine if this association varies by race and sex. Based on our previous work, we hypothesized that class II and III obesity (BMI ≥35 kg/m^2) would be associated with lower rates of colon cancer screening and that the obesity-related disparity would be most pronounced among white women.

Methods

Data Sources and Searches

We searched the PubMed, CINHAL, and Cochrane Library electronic databases from inception through November 1, 2006 using subject headings and key word terms for obesity and breast, cervical, and colon cancer screening (search terms available in Supplementary Tables 1–3). Results for mammography and Papanicolaou testing were published previously (5, 6). We completed an update of this search through February 9, 2011 with search terms that focused on obesity and colon cancer screening, and we report findings for articles on colon cancer screening identified from database inception through February 9, 2011 in this article. The manual search included review of the references of included articles and a review of the tables of contents of relevant journals. Two co-investigators reviewed titles, abstracts, and articles independently and resolved conflicts at the level of abstract and article review by consensus.

Study Selection

We included published, English language articles using original data to evaluate the relationship between obesity and colon cancer screening (fecal occult blood testing, sigmoidoscopy, and/or colonoscopy). We excluded studies not conducted in the United States because important determinants of cancer screening such as healthcare coverage (8) vary by country. We excluded studies conducted in special populations (e.g., subjects with a family history of colon cancer) for which screening recommendations and practices may differ (9, 10) and thus, obscure the association between obesity and cancer screening. We did not require a specific measure of adiposity or study design.

At the article review level, we identified several studies which analyzed the same data source, and we included only one article based on a given study population. Of the national studies, five analyzed data from the 2000 National Health Interview Survey (NHIS) (11–15), and two analyzed data from the 1999 Behavior and Risk Factor Surveillance System (BRFSS) (16, 17). The study population from the 2002 Maryland Cancer Survey was analyzed in three articles (18–20). For each of these cohorts, we selected the study meeting the most of the following criteria listed in descending order of importance: 1) The study provided adjusted results, 2) The study provided results using the following five BMI categories suggested by the National Heart, Lung, and Blood Institutes (21): Normal, 18.5–24.9 kg/m^2; overweight, 25–29.9 kg/m^2; class I obesity, 30–34.9 kg/m^2; class II obesity, 35–39.9 kg/m^2; and class III obesity, ≥ 40 kg/m^2, and 3) The study included the largest study population. We provide information about the studies excluded based on duplicate data in the appendix (Supplementary Table 4).

Data Extraction and Quality Assessment

All members of the study team have advanced training in clinical investigation including two senior obesity researchers (FLB and JMC). Using standardized forms, two investigators abstracted study design characteristics and results sequentially. Quality evaluation forms were developed using the STROBE checklist for guidance (22). Two investigators reviewed the quality of each study independently, and conflicts were resolved through consensus.

We contacted authors for additional quantitative results with a focus on obtaining race-sex stratified (for black and white race) results based on a black-white difference in the association of higher BMI with lower rates of Papanicolaou testing and mammography found previously (5, 6).

Data Synthesis and Analysis

We constructed tables to qualitatively describe the study design and report the results of each included study. Analyses were conducted using Stata version 11 (College Station, TX). We performed meta-analyses using a random effects model to combine effect estimates across studies (23). To perform a meta-analysis, we required that at least three studies address the research question overall or for a race-sex subgroup, and we only included studies in meta-analyses which reported body mass index in categories of normal (reference), overweight, class I obesity, class II obesity, and class III obesity. We defined moderate statistical heterogeneity as an I-squared statistic > 50% indicating that more than 50% of the variability across studies is due to heterogeneity (24). We investigated substantial heterogeneity using meta-regression for the following factors: Study type (nationally representative, national, regional, state, or local), sex of study participants (male, female, or both included), and adjustment of statistical models (unadjusted or adjusted) (25). We conducted sensitivity analyses evaluating the effect of removing any one study from each meta-analysis. To evaluate for bias resulting from the absence of small studies (often termed, “publication bias”), we examined funnel plots visually for asymmetry and also used the method of Egger et al to formally test for funnel plot asymmetry (26). We also used meta-regression to evaluate sex and race-sex category as sources of heterogeneity in the subset of studies which provided sex-specific and race-sex-specific results, respectively.

Results

Description of Included Studies

Of 5,543 citations reviewed, twenty-three articles met our inclusion criteria (Supplementary Figure 1) (13, 15, 17, 18, 27–45). We describe the design of the included studies in Table 1. The included studies represented ten national studies and three cancer-based cohorts. All other studies were regional, state-based, or local. Three studies included white subjects predominantly (29, 30, 41), two studies included only black subjects (33, 39), a single study included only Latino subjects (43), and another study included only Native American men (38). All other studies (N=16) were multi-ethnic. All studies were cross-sectional with the exception of one retrospective cohort study (44). Screening and BMI data were self reported in all studies except for four, in which at least some data came from medical records (28, 31, 36, 44) and another in which height was measured (40). All studies reported BMI as the measure of adiposity. Two studies used fecal occult blood testing as the sole component of their screening definition (33, 38); the remainder included sigmoidoscopy or colonoscopy or both.

Quality of Included Studies

Yang et al evaluated ethnicity as a predictor of colon cancer screening and adjusted this analysis for BMI, but the BMI-colon cancer screening methods and results were not reported specifically (45); thus, the following description of quality of included studies focuses on the remaining 22 studies. One study did not specify objectives or hypotheses regarding the BMI-colon cancer screening analyses (29). One study included subjects aged 41–49 years in analyses of colon cancer screening (39). Two studies did not specify the BMI categories clearly (35, 38), and two studies did not specify the colon cancer screening definition clearly (27, 33). Fifteen studies did not report on missing data for the BMI-screening analyses (13, 15, 27, 29, 31, 32, 34–40, 42, 44), and five reported <10% missing data (17, 28, 33, 41, 43). Two studies reported ≥10% missing data and did not address this issue in the analyses (18, 30). Twenty studies described all covariates completely, and two described most covariates (29, 38). The description of statistical methods was adequate (n=20) or fair (n=2) (38, 40) for all studies. Eleven studies accounted for confounding variables adequately (15, 17, 27, 28, 30, 32, 34, 35, 40, 42, 44); five fairly (18, 31, 33, 39, 43); and six inadequately (13, 29, 36–38, 41). Details on how the studies addressed confounding are provided in Supplementary Table 5.

Of four studies based in part on medical record review, none reported fully on procedures for data abstraction (28, 31, 36, 44). Additional quality information is provided in Supplementary Table 6.

Meta-analyses

Obesity was not significantly associated with colon cancer screening in the unstratified meta-analyses (Figure 1). There was evidence of substantial statistical heterogeneity (range of I^2 between 82 and 98%) for combined odds ratios across BMI categories (Supplementary Figure 2). Meta-regression did not reveal study type, sex, or adjustment of statistical models as a source of heterogeneity. Sensitivity analyses including only nationally representative studies (NHIS and BRFSS) provided a lower range of heterogeneity (I^2 between 0 and 64%) and confirmed the absence of a significant inverse association between BMI and colon cancer screening. The results of studies not included in the meta-analyses showed little evidence of a significant relationship between obesity and colon cancer screening and generally corroborated our meta-analysis results (Table 2).

We present results from studies reporting BMI-colon cancer screening analyses by sex only in Supplementary Table 7. Among studies providing quantitative results restricted on or stratified by sex, meta-regression revealed sex as a source of statistical heterogeneity for the class I obesity category ($P = 0.039$) while sex was not significantly predictive of screening for the other BMI categories (P value range, 0.159 to 0.334).

Among studies providing quantitative results restricted on or stratified by race and sex, meta-regression did not reveal race-sex dyad as a source of statistical heterogeneity (P = 0.93, 0.33, 0.37, and 0.53 for the overweight and class I, II, and III obesity categories, respectively). Within the subgroup of white women, obese white women reported significantly lower rates of colon cancer screening compared to those with a normal BMI, and this inverse association strengthened with increasing BMI category: Combined OR

(95% CI) were 0.98 (0.89 to 1.08), 0.87 (0.82 to 0.93), 0.80 (0.65 to 0.99), and 0.73 (0.58 to 0.94) for the overweight and class I, II, and III obesity categories compared to normal BMI, respectively, Figure 2). We found moderate heterogeneity for the meta-analyses comparing white women with class II (I^2 = 61%) and III (I^2 = 53%) obesity to those with a normal BMI (Supplementary Figure 3). With the exception of two studies (15, 45), the effect measures from all studies were consistent with the combined estimate of the odds ratio for the class II obesity category; omission of either of these two studies did not change the inference for this meta-analysis. For the class III obesity category, only the odds ratio estimate from Yang et al (45) was not consistent with the combined odds ratio, and omission of this study did not change the results. Meta-regression suggested study type as a possible source of heterogeneity ($P < 0.001$) for this BMI category.

White men with class II obesity reported significantly lower odds of colon cancer screening compared to those with a normal BMI (combined OR (95% CI), 0.83 (0.72 to 0.96)), and the combined OR white men with class III obesity did not reach statistical significance. We did not find a consistent inverse association between obesity and colon cancer screening among black men and women (Figure 2). Meta-analyses among class I obese white men demonstrated moderate heterogeneity (I^2 = 62%), and meta-regression did not reveal study type or statistical adjustment as a source of heterogeneity. Forest plots for these meta-analyses are provided in Supplementary Figures 3–6, and information about studies not included in the meta-analyses is provided in Supplementary Table 8.

No single study significantly influenced the meta-analysis results.

Bias Due Lack of Small Studies (Publication Bias)

Unstratified analyses comparing class II obese to normal weight individuals suggested a lack of small studies in which class II obese persons were more likely to undergo screening; inclusion of such studies would not likely change the inference of the meta-analysis result of no association. We also observed a paucity of small studies showing an association between class III obesity and increased screening among black men; this evaluation of bias was limited by the small number of studies (n=4). Publication bias was not apparent for all other analyses.

Discussion

BMI was not associated with lower rates of colon cancer screening overall. In the subgroup of white women, class I, II, and III obesity were associated with 13, 20, and 27% lower rates of colon cancer screening, respectively, relative to a normal BMI, and results suggested this inverse association may exist among white men with class II obesity as well. We did not find this association consistently in the subgroups of black men and women. Of the observational studies yielding these results, approximately 1/3 did not handle confounding adequately through statistical adjustment, stratification, or restriction. Our findings are consistent with previous systematic reviews of breast and cervical cancer screening suggesting an inverse association between BMI and mammography and Pap testing among white, but not black, women (5, 6). A prior systematic review of the association between obesity and colon cancer screening among women was inconclusive regarding the association (46); our study includes 15 additional studies and evaluates the impact of male sex and race.

While several factors may affect receipt of screening by obese patients (e.g., the presence of co-morbid conditions (47) precluding discussions of screening, provider discrimination (obesity bias) (48), and difficulties with endoscopy regarding bowel preparation and airway difficulties (49)), how race and sex might influence this, in particular why colon cancer screening rates may be lower for obese white persons, especially women, is unknown. Obese patients may avoid screening, when recommended, because of embarrassment related to disrobing in the setting of pervasive obesity stigmatization (48, 50, 51). This weight stigma seems to foster a negative body image in women more than men and, particularly in white women (48, 52). In a study in which white and black women rated magazine images of "thin, average weight, and large" black and white women, white women rated large white women lower in interpersonal and career domains while black women did not stigmatize large black women in this way (52).

A strength of this systematic review is the inclusion of results from a large number of studies evaluating predictors of colon cancer screening in both community-based and nationally representative study populations. To our knowledge, this is the first review to provide systematic and comprehensive evidence for the relationship between obesity and colon cancer screening in both men and women. Based on our prior work (5, 6), we designed this study to focus on this relationship in race-sex subgroups; in addition to conducting a thorough literature search, we contacted authors for the additional results that we report for race-sex subgroups.

A limitation of our evidence synthesis is heterogeneity of the definitions of adiposity and colon cancer screening across studies. While we included all studies in the qualitative synthesis regardless of adiposity measure used, we only included studies with BMI in specific categories in our meta-analyses. The impact of this requirement on our results is uncertain, but we felt that homogeneity in BMI categorization was important for the quantitative synthesis. Studies varied in their screening definition by modality (FOBT or endoscopy) and the screening interval (e.g., ever or only within the past year). Generally, definitions including both modalities and more permissive intervals should be more sensitive, but we do not know how the relationship between BMI and colon cancer screening might be different with different screening definitions. Therefore, we are unable to predict the effect of this heterogeneity, if any, on our results. Since screening definitions were more similar across studies for the race-sex meta-analyses, we anticipate that any possible effects of this heterogeneity were minimal for this aspect of our study.

While a key objective of our study was to evaluate the association between BMI and colon cancer screening across race-sex subgroups, we identified a relatively small number of studies for the race-sex analyses. Thus, the use of meta-regression to evaluate race-sex subgroup as a source of heterogeneity is likely underpowered. Point estimates from the meta-analyses conducted in race-sex subgroups, however, do lend support to our *a priori* hypothesis.

Limitations related to the design of the included studies also deserve mention. The included studies were observational and thus susceptible to both residual and unmeasured confounding which may bias our meta-analysis results. To address this, we included studies with adjusted results when possible, but adjustment variables and restrictions did vary across studies. Also, both BMI and receipt of colon cancer screening were self reported in most studies. Self reported BMI is highly correlated with measured BMI but is generally underestimated (53). Women tend to underestimate BMI more than men, but this gender difference narrows after the age of 40 (53), the age of our study populations. Furthermore, the National Health and Nutrition Epidemiologic Survey 2001–2006 did not find a significant difference in reporting of BMI by blacks compared to whites (53). In total, the underestimation of BMI should not affect the overall qualitative inference that increasing BMI is associated with lower rates of colon cancer screening in white women. A prior validation study found a sensitivity and specificity of self-reported screening endoscopy to be 79% and 90%, respectively, which did not differ by gender (54). Evidence comparing performance of self report between black and white participants was lacking (54). Thus, in our systematic review, colon cancer screening was likely underreported; whether this self-report of screening was differential by BMI is unknown but unlikely.

Identification of obesity as a possible barrier to colon cancer screening in white men and women underscores an important public health issue given the prevalence of obesity (55), suboptimal screening rates (4), and the substantial benefit of colon cancer screening for decreasing colon cancer risk and death (2, 56). One third of white adults in the United States are obese (55), and less than 40% of men and women over the age of 50 report colon cancer screening (4). It is therefore plausible that obesity-related under-screening contributes to the observed rates of obesity-related colon cancer incidence (35% and 13% increase in risk of colon cancer per 5 kg/m^2 increase in BMI in white men and women, respectively) (57) and obesity-related colon cancer death (relative risks in obese compared to normal weight ranging from 1.47 to 1.84 in white men and 1.33 to 1.46 in white women) (7). Our study suggests that obese white persons, an at-risk segment of the United States population for colon cancer morbidity and mortality, are not receiving an effective preventive service. Future research should identify cultural mediators of this relationship to address this disparity.

In summary, our systematic review demonstrates that obesity is not associated with lower rates of colon cancer screening in general but that there may be a graded relationship between increasing BMI and lower rates of colon cancer screening in obese white women and to a lesser extent in obese white men. While interventions to increase colon cancer screening rates across the population are necessary, the further investigation of the possible obesity-related disparity in white men and women may decrease colon cancer risk and death in the United States.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Additional Contributions: We thank the researchers who provided additional results from their studies upon our request: Carmela Groves, RN, MS, Center for Cancer Surveillance and Control, Maryland Department of Health and Mental Hygiene; Su-Ying Liang, PhD, Center for Translational Research and Policy Research on Personalized Medicine, University of California San Francisco; Lucia Leone, PhD, Department of Nutrition, University of North Carolina Gillings School of Global Public Health; Vijay Nandi, MPH, Center for Urban Epidemiologic Studies, The New York Academy of Medicine; Eileen Steinberger, MD, MS, Department of Epidemiology and Public Health, University of Maryland; Irene Tessaro, DrPH, MS, MSN, School of Nursing, West Virginia University; Christina Wee, MD, MPH, Division of General Internal Medicine and Primary Care, Beth Israel Deaconess Medical Center, Harvard Medical School; Marilyn Winkleby, PhD, MPH, Stanford University School of Medicine; Wei Yang, MD, PhD, University of Nevada, Reno.

Funding/support: Dr. Bolen’s time was supported by Grant number 1KL2 RR024990, National Center for Research Resources (NCRR) at the National Institutes of Health (NIH) and NIH Roadmap for Medical Research. Dr. Maruthur’s time was supported by a training grant (5T32 HL007180, National Heart, Lung, and Blood Institute of the NIH) and the Johns Hopkins Clinical Research Scholars Program (Grant number 1KL2 RR025006, NCRR at the NIH and NIH Roadmap for Medical Research). The contents of this manuscript are solely the responsibility of the authors and do not necessarily represent the official view of NCRR (58) or NIH.

Dr. Brancati’s time was supported by Grant number K24 DK62222 from the National Institute for Diabetes and Digestive and Kidney Disease (NIDDK) of the NIH and Grant number P60 DK079637 (Diabetes Research and Training Center) from the NIDDK of the NIH. Dr. Gudzune’s time was supported by a training grant from the Health Resources and Service Administration (Grant number T32 HP10025-16-00).

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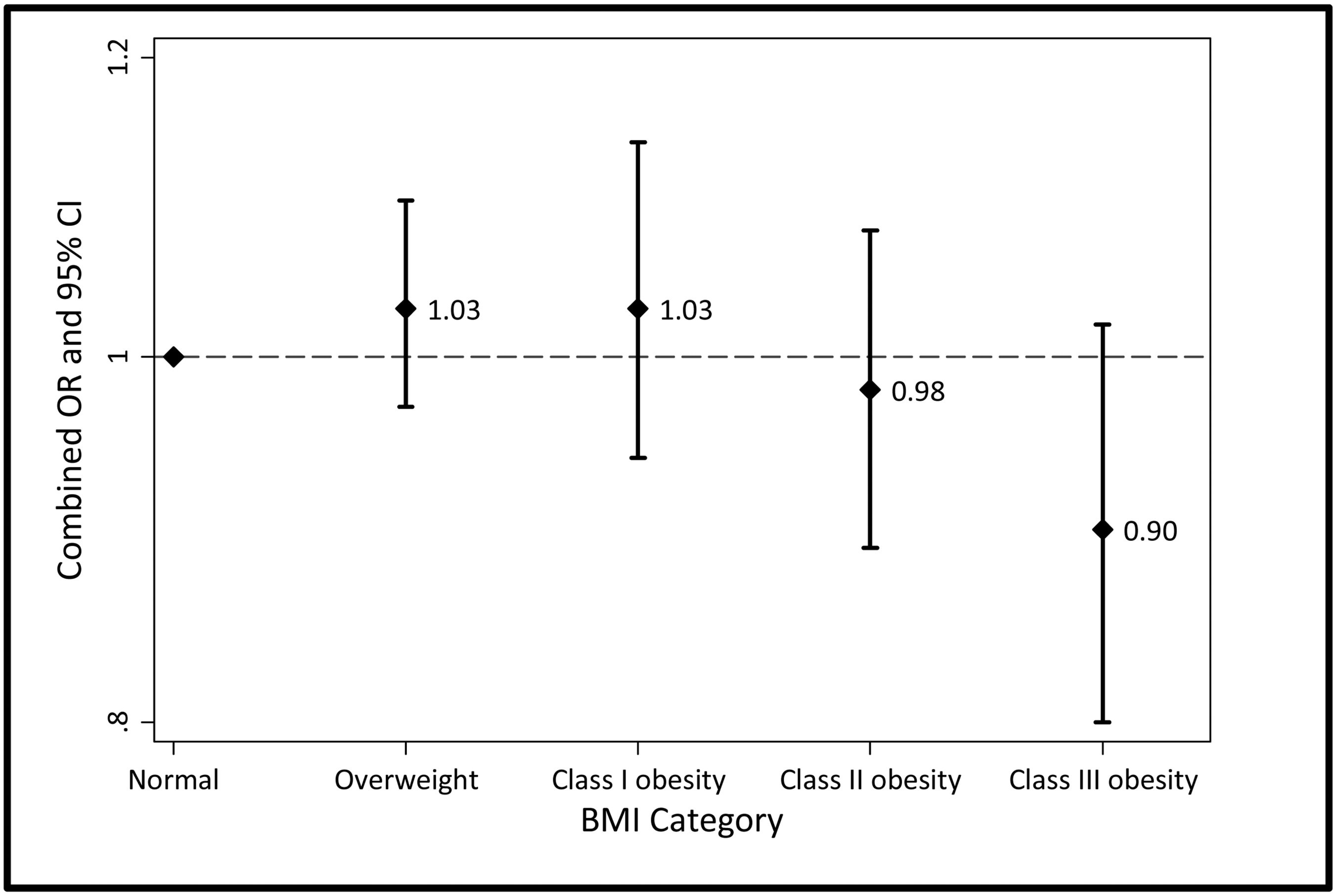

Figure 1. Combined odds ratios for colon cancer screening by BMI category

BMI Categories: normal, 18.5–24.9 kg/m^2 (reference); overweight, 25–29.9 kg/m^2; class I obesity, 30–34.9 kg/m^2; class II obesity, 35–39.9 kg/m^2; and class III obesity, ≥ 40 kg/m^2

Number of studies included in meta-analysis: Overweight, 15; Class I obesity, 12; Class II/III obesity, 11

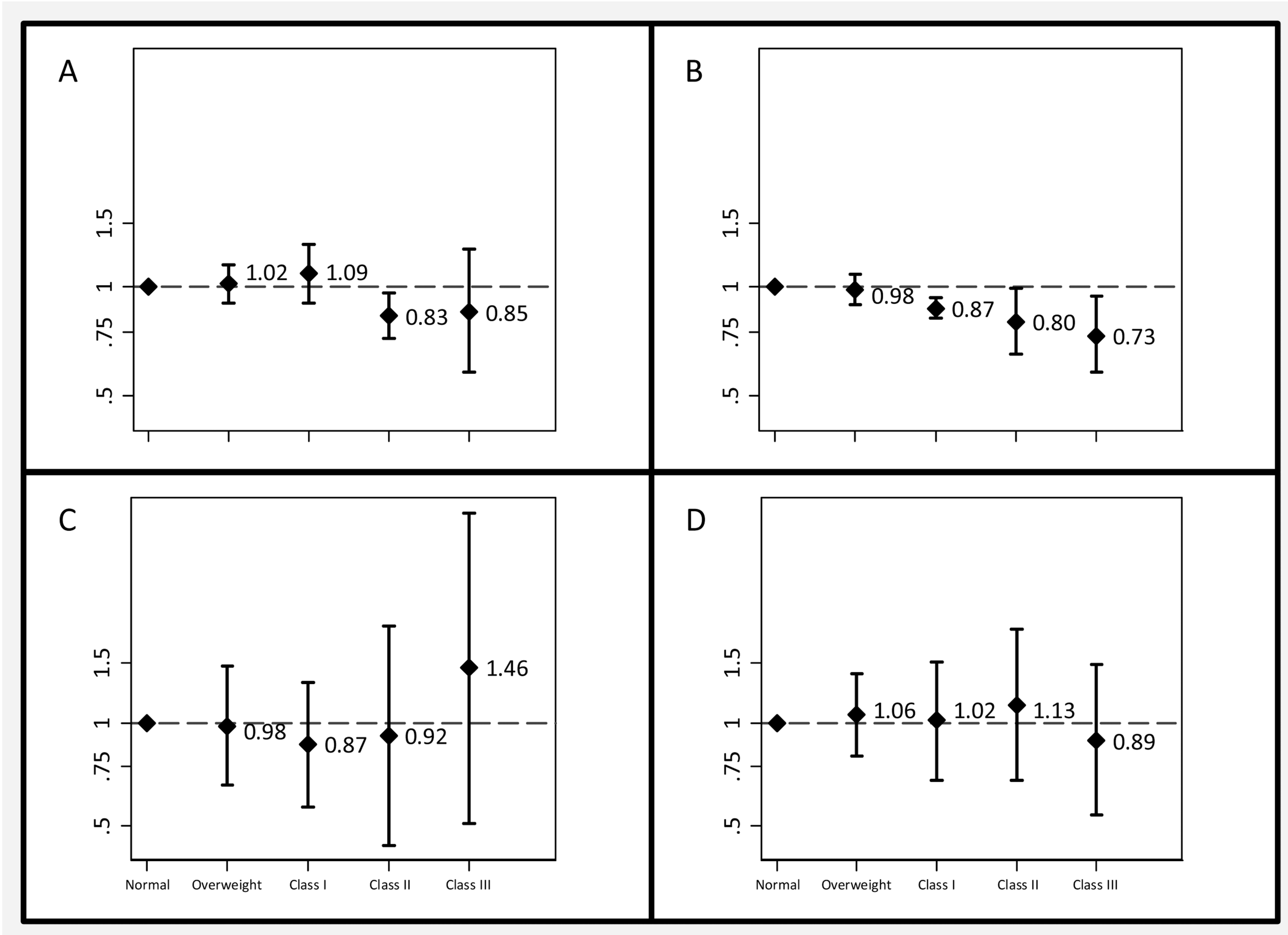

Figure 2. Combined odds ratios for colon cancer screening by BMI category by race and sex
Panel A . White men, *Panel B* . White women, *Panel C* . Black men, *Panel D* . Black women
BMI Categories: normal, 18.5–24.9 kg/m^2 (reference); overweight, 25–29.9 kg/m^2; class I obesity, 30–34.9 kg/m^2; class II obesity, 35–39.9 kg/m^2; and class III obesity, ≥ 40 kg/m^2
Number of studies included in meta-analysis: Panel A, 6; Panel B, 7; Panel C, 5 (class III obesity, 4); Panel D, 6

Table 1

Design of Included Studies

Author, Year	N	Study setting	% Women[a]	Race/ethnicity[a]	Data Collection
National					
Banerjea, 2008 (27)	4,256	MEPS 2003	100%	NR	Self-report via in-person interview
Chang, 2010 (28)	37,864	VA and MCBS	NR	NR	Self-report via in-person interview (MCBS); medical record review (VA)
Chao, 2004 (30)	129,246	Cancer Prevention Study II Nutrition Cohort	55%	White: 98%[b] Black: 1%	Self-report via mailed survey
Heo, 2004 (32)	84,284	BRFSS 2001	62%	White: 82%	Self-report via telephone interview
Ioannou, 2003 (17)	58,915	BRFSS 1999	61%	White: 85% Black: 6% Hispanic: 5.9% Asian: 1%	Self-report via telephone interview
Leone, 2010 (34)	7,469	NHIS 2005	100%	White: 86% Black: 14%	Self-report via in-person interview
Liang, 2006 (13)	11,779	NHIS 2003[c]	NR	NR	Self-report via in-person interview
McQueen, 2006 (37)	2,686	HINTS	63%	White: 74%	Self-report via telephone interview
Wee, 2005 (15)	11,427	NHIS 2000	NR	NR	Self-report via in-person interview
Yancy, 2010 (44)	1,699,219[d]	VA 2000–2005	NR	NR	Medical record review
Regional					
Ferrante, 2006 (31)	1,297	Mid-Atlantic primary care practices	49%	White: 80%[e] Black: 9% Asian/Pacific Islander: 3% Other: 8% Hispanic: 4%	Medical record review
Matthews, 2007 (36)	104	Midwestern medical clinics	68%	White: 62% Black: 47.8%	Self-report via in-person interview and verification by medical record review
Muus, 2009 (38)	2,447	National Resource Center on Native American Aging	0%	Native American: 100%	Self-report via in-person interview
Slattery, 2004 (40)	2,479	Controls from HMO (Northern California) and community-based (Utah) case-control study	45%	White: 82–87%	In-person self-report of weight, measured height
Tessaro, 2006 (41)	802	16 Appalachian churches	65%	White: 98%	Self-administered survey completed in church
State					
James, 2008 (33)	378	Churches in rural North Carolina	72%	Black: 100%	Self-report via telephone interview
Lian, 2008 (35)	2,987	BRFSS 2006 (Missouri)	62%	White: 87%	Self-report via telephone interview

Author, Year	N	Study setting	% Women[a]	Race/ethnicity[a]	Data Collection
				Black: 7% Hispanic: 5%	
Menis, 2006 (18)	3,017	Maryland Cancer Survey 2002	62%	White: 79% Black: 17% Other: 4%	Self-report via telephone interview
Satia, 2007 (39)	405	North Carolina Department of Motor Vehicles rosters	56%	Black: 100%	Self-report via mailed survey, telephone, or Internet
Yang, 2009 (45)	2,478	BRFSS 2004–06 (Nevada)	NR	White: 85%[b] Hispanic: 15%	Self-report via telephone interview
Local					
Chao, 1987 (29)	11,888	Retirement community-based cohort study in Southern California	64%	Predominantly White	Self-report via mailed survey
Vlahov, 2005 (42)	5,362	New York Cancer Project (New York City)	67%	White: 55.9% Black: 14.7% Asian: 10.3% Hispanic: 15.2%	Self-report via in-person interview
Winkleby, 2003 (43)	98	Monterrey County (California) in residential community and agricultural camp	55%[b]	Latino: 100%	Self-report via telephone interview (men and women) and in-person interview (men in agricultural camp)

Abbreviations: NR, not reported; VA, Veterans' Administration; MCBS, Medicare Beneficiary Survey; BRFSS, Behavior Risk Factor and Surveillance Survey; NHIS, National Health Interview Survey; HINTS, Health Information Trends Survey

[a]Proportion based on obesity-colon cancer screening analysis.

[b]Proportions calculated using results kindly provided by authors.

[c]Results presented for NHIS 2003 since other studies provided results from NHIS 2000

[d]Number of participants in entire study population and not limited to obesity-colon cancer screening analysis

[e]Racial composition of included practices, not specifically for the study population

Table 2

Relationship between Obesity and Colon Cancer Screening

Author, Year	Reference BMI	Screening definition[a]	Results (Adjusted OR, 95%CI)
National			
Chang, 2010 (28)	Normal BMI	Any screening	Medicare Current Beneficiary Survey
			Overweight: 0.98 (0.88 to 1.10)
			Obese: 0.98 (0.86 to 1.12)
			Veterans Administration
			Overweight: 1.12 (1.04 to 1.20)
			Obese: 1.02 (0.95 to 1.09)
Chao, 2004 (30)[b]	Normal BMI	Endoscopy in past 5 years	Overweight: 0.93 (0.90 to 0.976)
			Class I: 0.88 (0.84 to 0.93)
			Class II: 0.81 (0.73 to 0.90)
			Class III: 0.71 (0.60 to 0.85)
Heo, 2004 (32)	Normal BMI	Any screening:	Overweight: 1.15 (1.02 to 1.31)
		FOBT in past year	Class I: 1.21 (1.09 to 1.35)
		Flexible sigmoidoscopy in past 5 years[c]	Class II: 1.17 (1.04 to 1.44)
			Class III: 1.27 (1.05 to 1.58)
Ioannou, 2003 (17)	<25 kg/m^2	FOBT in past year	Class I+II: 1.0
		Endoscopy in past 5 years	Class III: 0.8[d]
Liang, 2006 (13)[a,e]	Normal BMI	Any screening	Overweight: 1.03 (0.91 to 1.18)
			Class I: 1.06 (0.90 to 1.25)
			Class II: 0.85 (0.66 to 1.10)
			Class III: 0.90 (0.66 to 1.21)
McQueen, 2006 (37)[a]	< 25 kg/m^2	Endoscopy in last 10 years[e,f]	<25: 49%
		FOBT in past year	Overweight: 47%
			Obese: 50%
Wee, 2005 (15)	Normal BMI	Any screening	Overweight: 1.1 (1.0 to 1.2)
			Class I: 1.0 (0.9 to 1.2)
			Class II: 1.1 (0.9 to 1.4)
			Class III: 1.1 (0.8 to 1.5)
Regional			
Ferrante, 2006 (31)	< 30 kg/m^2	Any screening:	Obese: 0.75 (0.61 to 0.91)
		FOBT in past year	
		Flexible sigmoidoscopy in past 5 years	
		Colonoscopy in past 10 years	
		Barium enema in past 5 years	
Matthews, 2007 (36)	< 25 kg/m^2	Any screening	Overweight/obese: 1.98 (0.65 to 6.02)[e]
Slattery, 2004 (40)	< 25 kg/m^2	Flexible sigmoidoscopy in past 10 yrs	Overweight: 1.5 (1.2 to 2)
			Obese: 1.2 (0.9 to 1.6)
Tessaro, 2006 (41)[a,e]	Normal BMI	Any screening:	Overweight: 0.92 (0.87 to 0.97)

Author, Year	Reference BMI	Screening definition[a]	Results (Adjusted OR, 95%CI)
		FOBT in past year	Class I: 1.11 (1.02 to 1.21)
		Flexible sigmoidoscopy in past 5 years	Class II: 1.08 (0.85 to 1.39)
		Colonoscopy in past 10 years	Class III: 0.21 (0.10 to 0.87)
		Barium enema in past 5 years	
State			
James, 2008 (33)[a,e]	Normal BMI	FOBT in past year	Overweight: 0.75 (0.41 to 1.40)
			Class I: 0.52 (0.26 to 1.03)
			Class II: 0.70 (0.26 to 1.84)
			Class III: 0.80 (0.26 to 2.45)
Lian, 2008 (35)	< 25 kg/m^2	Any screening	Overweight: 1.40 (1.04 to 1.88)
			Obese: 1.57 (1.13 to 2.18)
Satia, 2007 (39)	Normal BMI	Endoscopy in past 10 years	Obese: 1.25
Menis, 2006 (18)[a]	< 25 kg/m^2	Any screening:	Overweight: 1.03 (0.81 to 1.32)
			Class I: 0.91 (0.68 to 1.23)
			Class II: 0.66 (0.42 to 1.04)
			Class III: 0.66 (0.37 to 1.18)
Yang, 2009 (45)[a]	Normal BMI	Ever had endoscopy at/after age 50	Overweight: 1.14 (0.87 to 1.50)
			Class I: 1.46 (1.09 to 1.96)
			Class II: 1.29 (0.74 to 2.27)
			Class III: 0.86 (0.49 to 1.52)
Local			
Vlahov, 2005 (42)[a,e]	Normal BMI	Endoscopy in past 5 years	Overweight: 0.92 (0.8 to 1.07)
			Class I: 1 (0.83 to 1.2)
			Class II: 0.93 (0.7 to 1.23)
			Class III: 0.64 (0.46 to 0.9)

Abbreviations: BMI, body mass index; OR, odds ratio; FOBT, fecal occult blood testing.

BMI categorization: Normal BMI (18.5 – 24.9 kg/m2); overweight (25– 29.9 kg/m2); class I obesity (30 – 34.9 kg/m2); class II obesity (35 – 39.9 kg/m2); class III obesity (≥ 40 kg/m2)

[a] Any screening: FOBT in past year, flexible sigmoidoscopy in past 5 years, or colonoscopy in past 10 years

[b] Authors kindly provided additional results upon request.

[c] Authors report results for flexible sigmoidoscopy in past 5 years and report that BMI not associated with FOBT in past year.

[d] P > 0.05 for all analyses.

[e] Unadjusted results

[f] Endoscopy results reported