Published in final edited form as:
*Cancer Causes Control*. 2012 February ; 23(2): 289–296. doi:10.1007/s10552-011-9878-5.

# Adverse Events after Screening and Follow-up Colonoscopy

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## Abstract

**Objective—**We provide new information about how the risk of adverse events following colonoscopy varies by age and indication (screening versus follow-up performed to evaluate a positive result from another screening modality).

**Methods—**We constructed a retrospective cohort comprised of 43,456 individuals aged 40 to 85 years enrolled in a large integrated healthcare organization in Washington state who underwent outpatient colonoscopy between 1994 and 2009. We calculated rates of serious adverse events (perforation, hemorrhage, and acute diverticulitis) in the 30 days following colonoscopy and compared rates using log-binomial regression models.

**Results—**We observed 4.7 serious adverse events per 1000 screening colonoscopies and 6.8 per 1000 follow-up colonoscopies. Polypectomy increased the rate of serious adverse events (relative rate [RR], 2.64; 95% confidence interval [CI], 1.97–3.56). Older age was associated with increased risk of serious adverse events, after adjusting for polypectomy, gender, and indication. Compared to individuals aged 50–64 years, risk was elevated for those aged 65–74 (RR, 1.93; 95% CI, 1.40–2.65) and 75–85 (RR, 3.21; 95% CI 2.14–4.86). We observed similar age effects in individuals with and without significant comorbid conditions.

**Conclusions—**The risks of serious adverse events following colonoscopy performed as part of screening are low, but increase with age and are more likely after polypectomy.

## Introduction

There is little debate that colorectal cancer (CRC) screening in individuals aged 50–75 years reduces CRC mortality,(1–5) with approximately half of the recent decline in CRC incidence attributed to screening.(6) Colonoscopy can prevent CRC through detection and removal of adenomas, and the use of colonoscopy for screening is increasing.(7–9). However, serious complications can follow colonoscopy including death, hospitalization, perforation, major bleeding, diverticulitis, cardiovascular events, and/or serious abdominal pain.(3, 10–13) Because complications are rare, their study requires the use of large datasets allowing estimation of adverse events following colonoscopy, which includes both events directly related to colonoscopy (complications) and other coincidental events.

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Studies examining risks of adverse events following colonoscopy have not distinguished between the four main indications for colonoscopy, which are *screening* of asymptomatic individuals with no clinical indications of CRC, *follow-up* for evaluation of positive results from another CRC screening test, *diagnostic work-up* for evaluation of symptoms, and *surveillance* of individuals with a history of colorectal adenomas. Instead, analyses have estimated rates of adverse events following colonoscopy by combining screening, follow-up, and diagnostic colonoscopy. Separating risk by screening indication is important, because although the expected benefit is greater among individuals undergoing diagnostic, surveillance, or follow-up exams than those receiving screening exams, the risks may be higher from an increased chance of polypectomy. Thus, screening colonoscopy risks may be overestimated by studies that include data from diagnostic colonoscopy.

CRC screening in individuals aged 50–75 years reduces CRC mortality,(1–5) and average risk individuals are recommended to begin CRC screening at age 50. After Medicare began covering screening colonoscopy in 2001, the use of screening colonoscopy rapidly increased, with a corresponding decrease in fecal occult blood testing and flexible sigmoidoscopy.(7) However, this has occurred in the absence of sufficient evidence on screening colonoscopy risks that would help individuals make informed, shared decisions with their providers about CRC screening modalities. To address this evidence gap, we used data from a large population-based cohort to examine adverse event rates, stratified by age, following colonoscopy performed for screening or to follow up a screening assessment. Our results offer a more detailed analysis of screening colonoscopy risks.

## Methods

This retrospective cohort study included individuals 40 to 85 years old who had an outpatient screening or follow-up colonoscopy between 1994 and 2009 at a large, nonprofit, consumer-governed health care system in Washington State that integrates care and coverage for over 600,000 members. Between 1997 and 2010, the preferred screening option for average-risk individuals was Hemoccult SENSA (Beckman Coulter, Fullerton, California) in conjunction with flexible sigmoidoscopy. Colonoscopy was covered as a screening modality in 2001, when Medicare began coverage for screening colonoscopy.(14, 15)

### Colonoscopies

We focused on risk following screening and follow-up colonoscopy, performed in an outpatient community setting. To be included in the sample, we required individuals to have at least six months of continuous enrollment prior to a colonoscopy and enrollment for 30 days after the exam unless the subject died during this period. When individuals had multiple exams, we included only the first eligible colonoscopy.

We used automated data in combination with four criteria to exclude diagnostic colonoscopies, that is, exams carried out to evaluate symptoms. First, we excluded colonoscopy codes associated with diagnostic procedures: endoscopic hemostasis of a bleeding colonic lesion, insertion of a colonic stent, endoscopic colonic dilatation, and endoscopic reduction of a sigmoid volvulus (16). Second, we excluded colonoscopies in individuals with a visit in the six months prior to colonoscopy that resulted in a diagnosis associated with gastrointestinal or colorectal cancer symptoms, including diarrhea, abdominal pain, gastrointestinal bleeding, and anemia. Third, we excluded colonoscopies in individuals who had an upper endoscopy in the seven days before colonoscopy, as this suggests that the colonoscopy was part of a diagnostic evaluation, and individuals with abdominal imaging in the 90 days prior to colonoscopy, in whom incidental findings may have lead to follow-up diagnostic colonoscopy. Fourth, we excluded colonoscopies with a

negative fecal occult blood test in the prior 6 months as potentially diagnostic. We were unable to exclude based on prior results from barium enema or flexible sigmoidoscopy, because this information is not captured within available utilization data. We excluded individuals with a prior diagnosis of inflammatory bowel disease, ulcerative colitis, or Crohn's disease because colonoscopy may guide treatment in these patients (rather than being used specifically for CRC screening)(17) and these patients are at increased risk for CRC(18, 19). We also excluded individuals who underwent colonoscopies after colonic resection or diagnosis with any non-melanoma cancer because these individuals were not eligible for usual screening for incident CRC.

Follow-up colonoscopies were defined by receipt of another CRC screening test (fecal occult blood tests, flexible sigmoidoscopy, or barium enema) in the prior six months. We used procedure codes to categorize colonoscopies as with or without polypectomy based on indications of either polypectomy or biopsy as part of the procedure (biopsy: CPT 45380; polypectomy: CPT 45383, 45384, 45385 and ICD9 45.43, 48.36). We also used procedure codes to identify use of "hot" procedures that use cautery to simultaneously remove and electrocoagulate tissue, to explore whether the use of heat was associated with increased risk for complications (such as abdominal pain that may be associated with serosal burns). Codes used in our inclusion and exclusion criteria are included in the Appendix.

### Outcomes: Adverse Events

We examined adverse events occurring within 30 days after the index colonoscopy. Outcomes examined were death, hospitalization, perforation, hemorrhage, acute incident diverticulitis (ICD9 562.11 and 562.13), dehydration, and abdominal pain, identified using ICD-9 codes. We also examined acute-care utilization during the 30 days after colonoscopy, including hospitalization and emergency department and urgent care visits. Hospitalizations excluded individuals with CRC detected within two months of the colonoscopy, to avoid inclusion of hospitalizations associated with cancer care.

### Statistical Analysis

We describe overall rates of serious adverse events following screening colonoscopy, and compare rates by age group, indication (screening or follow-up), polypectomy (yes/no), and Klabunde comorbidity score (20) using log-binomial regression models that adjust for relevant covariates (e.g., models that examine the effect of age on complication rates adjusted for polypectomy and exam year). All regression models included at least 20 events per predictor. The Klabunde comorbidity score uses diagnostic and procedure codes to identify individuals who may have comorbid conditions that place them at increased risk for death in the following two years.

## Results

We identified 158,295 colonoscopies performed between 1994 and 2009. Of these, 43,515 (29%) of procedures in 43,456 patients met the study criteria as likely screening or follow-up colonoscopies. In this 16-year window, most individuals included in our cohort (99.9%) had only one colonoscopy.

The number of screening colonoscopies increased sharply over time, reflecting changes in screening recommendations and uptake, while the number of follow-up colonoscopies was stable (Table 1), consistent with observed stable rates of fecal-based screening within this health care system. Screening colonoscopies accounted for 41% of all colonoscopies (screening or follow-up) in 1994–1997, 63% in 1998–2001, 89% in 2002–2005, and 95% in 2006–2009. Overall, more than half of the identified screening colonoscopies were

performed in the last 4 years (2006–2009) of our 16-year study period. We found no evidence of changes in overall rates of polypectomy or in the type of polypectomy (hot or cold) over time. We had limited ability to examine the impact of type of polypectomy. Only 9.4% of polypectomies used cautery, and we found no obvious secular trends in rates of cauterizing procedures (1994–1997: 5.4% of polypectomies used cautery; 1998–2001: 17%; 2002–2005: 13%; 2006–2009: 7.1%).

The age of individuals undergoing a screening or follow-up colonoscopy decreased over the study period, from an average of 62.4 years before 2000 to 57.9 years in 2006–2009. The proportion of colonoscopies with polypectomy increased slightly with age, occurring in 43% of the group aged 40–49 years, 47% of the 50–64 group, 52% of the 65–74 group, and 50% of the 75–85 group. Most individuals undergoing screening or follow-up colonoscopy were free of comorbid conditions; 80% had a Klabunde comorbidity score equal to 0, indicating no significant comorbid conditions associated with increased mortality.

## Serious Adverse Events

In the 30 days post-procedure, we observed 4.7 serious adverse events per 1000 screening colonoscopies and 6.8 per 1000 follow-up colonoscopies. Polypectomy was only slightly more likely to occur with follow-up colonoscopies (52% of exams) compared to screening colonoscopies (47% of exams). The percentage of follow-up colonoscopies increased with increasing age (40–49: 7%; 50–64: 9%; 65–74: 20%; 75–84: 29%). The estimated relative rate [RR] of serious adverse events for screening versus follow-up colonoscopy was 0.96 (95% CI, 0.62–1.47), based on a model that adjusted for age, gender, polypectomy, and year of exam. In the subgroup with no Klabunde comorbidity, the rate of serious adverse events was slightly lower in the follow-up colonoscopy group than the screening group (RR 0.73; 95% CI, 0.41–1.30).

Serious adverse events were more likely after polypectomy (unadjusted rates of 2.7 per 1000 without polypectomy, 7.4 per 1000 with polypectomy). The estimated rate of serious adverse events following colonoscopy with polypectomy relative to colonoscopy without polypectomy was 2.64 (95% CI, 1.97–3.56), based on a model that adjusted for gender, indication (screening or follow-up) and age at procedure. We found no evidence of secular changes in adverse event rates following colonoscopy (1994–1997: 3.8/1000 colonoscopies; 1998–2001: 10.3/1000; 2002–2005: 5.7/1000; 2006–2009: 4.0/1000). The estimated relative rates of serious adverse events following colonoscopy compared to 2006–2009 rates were (with 95% CIs): 1994–1997, 0.70 (0.31–1.54); 1998–2001, 2.05 (1.33–3.14); 2002–2005, 1.40 (1.03–1.90), based on models that adjusted for age, gender, polypectomy, and exam indication. We found no evidence for secular trends in the rate of polypectomy.

Table 2 describes specific adverse events following colonoscopy overall, by exam indication, and with or without polypectomy. Of individuals with at least one adverse event, only 16% had multiple events. Abdominal pain was the most common co-occurring adverse event, identified in 29% of individuals with perforation, 18% of individuals with hemorrhage, 28% of individuals with incident diverticulitis, and 17% of individuals with urgent care visits. Abdominal pain was also the most common adverse event overall (25.9 per 1000), although abdominal pain associated with a same-day hospitalization was rare (0.3 per 1000 colonoscopies). Dehydration was only rarely indicated in ICD-9 codes (1.1 per 1000 colonoscopies).

We observed 15 deaths in the 30 days following colonoscopy, corresponding to 0.3 deaths per 1000 colonoscopies. However, in 8 of 15 people with cause-of-death information, none were attributed to perforation or colonoscopy complications. Perforation was also rare, occurring in 0.5 per 1000 colonoscopies, with higher rates among those with polypectomy

than those without (0.6 versus 0.3 per 1000). Hemorrhage was more common than perforation, and like perforation, occurred more often among those with polypectomy than those without.

### Hospitalization and Urgent-Care Visits

The overall rate of hospitalization in the 30 days following screening colonoscopy was 11.6 per 1000 colonoscopies. Hospitalization rates were twice as high after a colonoscopy with polypectomy than colonoscopy without polypectomy (14.3 per 1000 versus 9.4 per 1000). The risk of hospitalization following colonoscopy with polypectomy relative to colonoscopy without polypectomy was 1.48 (95% CI, 1.24–1.77), adjusting for gender, indication, and age at time of procedure. Monthly hospitalization rates in the GH population have been relatively stable over the study period, at approximately 10 per 1000.

The monthly rate of emergency department and urgent care use was 23.4 visits per 1000 colonoscopies, with similar rates for those with and without polypectomy: 24.7 per 1000 colonoscopies with polypectomy versus 22.3 per 1000 colonoscopies without. Approximately 10% of individuals with an emergency department or urgent care visit were hospitalized during the 30 days after colonoscopy.

### Age Effects

Table 3 shows adverse events in the 30 days following screening colonoscopy by age. Subsequent diagnoses of abdominal pain were most common in the youngest age group (6.4% of colonoscopies in 40- to 49-year-olds versus 2.2%–3.5% in the older age groups). Older age was associated with higher rates of perforation, and hemorrhage, and subsequent diagnosis of diverticulitis. Overall, older age was associated with a higher rate of serious adverse events: 4.2 per 1000 for ages 40–49, 3.7 per 1000 for ages 50–64, 7.9 per 1000 for ages 65–74, and 13.3 per 1000 for ages 75–84. Across age groups, the estimated relative rate of serious adverse events following colonoscopy, compared to 50–64 year-olds was (with 95% CIs): 1.07 (0.58–1.98) for subjects aged 40–49 years, 1.93 (1.40,−2.65) for 65–74 years, and 3.21 (2.14–4.86) for 75–85 years, adjusting for gender, procedure year, indication, and polypectomy. Similar results were seen in those with a Klabunde score of zero, with relative rates of 1.16 (0.58–2.32) for 40–49 years, 1.83 (1.21–2.77) for 65–74 years, and 3.37 (2.00–5.65) for 75–85 years.

## Discussion

This study adds to our knowledge about the risks of adverse events following screening colonoscopies, including detailed estimates of adverse event rates in individuals between the ages of 40 and 64, when many people initiate CRC screening. Adverse events rates were similar among individuals undergoing screening and follow-up colonoscopy after adjusting for polypectomy. However, the rate of serious adverse events (perforation, hemorrhage, diverticulitis) increased with age, even after adjusting for polypectomy. While adverse events remained unlikely, particularly in younger age groups, the risk of serious adverse events was three times higher among 75- to 84-year-olds compared to 50- to 64-year-olds. This increased potential risk of colonoscopy complications must be balanced against an individual's potential benefit from CRC detection and prevention. While individuals over 75 are at increased risk for incident CRC compared to younger individuals, the potential benefit from primary prevention due to adenoma removal may be reduced, given the remaining life expectancy.

Our results parallel findings from Warren and colleagues(12), who used a matched cohort study of Medicare beneficiaries 66 years and older to examine the risk of serious adverse

events following colonoscopy performed from 2001 to 2005. They found that individuals who underwent screening or diagnostic colonoscopy were at increased risk of serious gastrointestinal (GI) events (perforation, gastrointestinal bleeding, administration of blood transfusions), reporting 6.9 serious GI events per 1000 screening and diagnostic colonoscopies, and 2.4 serious GI events per 1000 screening colonoscopies without polypectomy. However, age effects may be related to pre-procedure warfarin use.(13)

Changes in colonoscopy risk with age are particularly important given the increased use of colonoscopy as a screening modality.(7–9) In their 2008 screening guidelines, the US Preventive Services Task Force recommended against routine screening in individuals older than 85 years, noting that “the benefits of detection and early intervention decline after age 75 years” because of competing causes of mortality.(4) Guidelines issued by the US Multi-Society Task Force(2) and the American College of Gastroentrology(5) do not address upper age limits for CRC screening and no guidelines discuss how the risk-benefit trade-off for different screening modalities shifts as an individual ages. Future studies should consider whether a less invasive test, such as fecal occult blood tests, may provide benefit with fewer risks in individuals over age 75.

Our overall rate of adverse events, 4.7 per 1000 screening colonoscopies, was somewhat higher than previous reports on adverse events following colonoscopy. However, these earlier studies did not distinguish between screening, follow-up, diagnostic, and surveillance colonoscopies and analyzed data from periods when screening colonoscopy was relatively less common. A 2008 meta-analysis estimated 2.8 serious adverse events per 1000 colonoscopies (95% CI, 1.5–5.2), where serious adverse events included death, hospitalization, perforation, major bleeding, diverticulitis, cardiovascular events, and/or serious abdominal pain.(3) Singh and colleagues (11) estimated 2.9 serious complications per 1000 colonoscopies between 2004 and 2006 in a Canadian sample, using chart review to examine a broad range of complications including acute myocardial infarctions, renal failure, dehydration, intestinal obstruction, episodes of pneumonia and acute diverticulitis, severe abdominal pain, hemorrhage, and perforation. Based on surveys of patients who had undergone screening or diagnostic colonoscopy, Ko and colleagues estimated only 2.0 complications per 1000 colonoscopies.(13)

Consistent with previous studies, we found that serious adverse events were more likely following polypectomy. Although adenoma prevalence increases with age,(21) the proportion of colonoscopies with polypectomy did not increase strongly with age, ranging from 43% to 52%. This may be attributable to differential screening test selection: 50-to 64-year-olds had both the highest rate of follow-up colonoscopy and the highest rate of colonoscopy with polypectomy. The percentage of colonoscopies with polypectomy may also be higher in younger members of our cohort than would be expected for the general population because individuals with a family history of CRC were more likely to be screened at earlier ages. In addition, the percentage of colonoscopies with polypectomy may be lower in older members of our cohort than would be expected in a prevalence screening study if some individuals had previously undergone colonoscopy either outside of the study period or outside of the delivery system.

Our study has several limitations. We relied on procedure and diagnosis codes to determine indication for colonoscopy and occurrence of events linked to colonoscopy. This could result in inclusion of some events that were not a direct result of colonoscopy. Because we did not carry out a chart review, we focused on events that are likely to be associated with colonoscopy and did not consider outcomes such as cardiovascular events that may or may not be linked to colonoscopy. For example, we did not examine cardiopulmonary events that are related to sedation during colonoscopy.(22) Another limitation is our use of procedure

and laboratory data to determine indication for colonoscopy. Through extensive exclusion criteria, we aimed to include only screening and follow-up colonoscopies at the expense of misclassifying some exams as diagnostic. However, it is possible that some diagnostic exams were included. In addition, we did not specifically exclude colonoscopies resulting from adenoma surveillance, though we only included the first exam. Some misclassification of screening and follow-up colonoscopies may also have occurred, for example, individuals seeking follow-up after an outside screening test without an associated claim record would be misclassified as screening colonoscopy. Focusing on first exams may limit the generalizability of our findings, if complication rates are systematically higher (or lower) for subsequent exams. We relied on procedure codes to determine the use of electrocautery, so it is possible that we did not fully capture these procedures. We also had limited ability to examine mechanisms that may drive age effects, although we found that among individuals without significant comorbid conditions, older individuals continued to be at greater risk for complications following screening colonsocopy. Specifically, we were unable to adjust for pre-exam medication use, which likely increases with age, even among those without serious complications. While we could have examined pre-exam prescriptions for warfarin, we could not provide conclusive results because we could not determine temporary cessation in medications or capture use of non-prescription medications (nonsteroidal anti-inflammatory drugs) associated with increased risk of bleeding. Similarly, we could not adjust for the number or size of lesions removed. The number of adenomas removed is likely to increase with age, and the risk for serious complications is likely to increase with each polypectomy. Similarly, removal of larger adenomas may carry greater risk that removal of smaller adenomas, and older individuals may be more likely to have large adenomas.

Our study provides new information about complications following screening and follow-up colonoscopy, both overall and among individuals 40- to 64-years-old, and adds to the general evidence about complications following colonoscopy. Rates of serious complications are rare, especially among younger individuals. These immediate risks are balanced by the longer term benefits of decreased risk for CRC. Overall, our results are reassuring for individuals considering a first screening colonoscopy at age 50.

## Acknowledgments

Supported by NCI U01 CA97427 and NCI U01 CA152959

## References

1. Lieberman D. Progress and challenges in colorectal cancer screening and surveillance. Gastroenterology. 2010; 138(6):2115–26. [PubMed: 20167216]
2. Levin B, Lieberman DA, McFarland BG, Andrews KS, Brooks D, Bond J, et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: A joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. Gastroenterology. 2008; 134(5):1570–1595. [PubMed: 18384785]
3. Whitlock EP, Lin JS, Liles E, Beil TL, Fu R. Screening for colorectal cancer: a targeted, updated systematic review for the U.S. Preventive Services Task Force. Ann Intern Med. 2008; 149(9):638–58. [PubMed: 18838718]
4. U S. Preventive Services Task Force. Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2008; 149(9):627–37. [PubMed: 18838716]
5. Rex DK, Johnson DA, Anderson JC, Schoenfeld PS, Burke CA, Inadomi JM, et al. American College of Gastroenterology guidelines for colorectal cancer screening 2009 [corrected]. Am J Gastroenterol. 2009; 104(3):739–50. [PubMed: 19240699]

6. Edwards BK, Ward E, Kohler BA, Eheman C, Zauber AG, Anderson RN, et al. Annual report to the nation on the status of cancer, 1975–2006, featuring colorectal cancer trends and impact of interventions (risk factors, screening, and treatment) to reduce future rates. Cancer. 2009; 116(3): 544–573. [PubMed: 19998273]
7. Schenck AP, Peacock SC, Klabunde CN, Lapin P, Coan JF, Brown ML. Trends in colorectal cancer test use in the medicare population, 1998–2005. Am J Prev Med. 2009; 37(1):1–7. [PubMed: 19423273]
8. Richardson IC, Rim SH, Plescia M. Vital Signs: Colorectal cancer screening among adults aged 50–75 years - United States, 2008. MMWR Morb Mortal Wkly Rep. 2010; 59:808–812. [PubMed: 20613704]
9. Holden DJ, Harris R, Porterfield DS, Jonas DE, Morgan LC, Reuland D, et al. Enhancing the use and quality of colorectal cancer screening. Evid Rep Technol Assess (Full Rep). 2010; (190):1–195. [PubMed: 20726624]
10. Levin TR, Zhao W, Conell C, Seeff LC, Manninen DL, Shapiro JA, et al. Complications of colonoscopy in an integrated health care delivery system. Ann Intern Med. 2006; 145(12):880–6. [PubMed: 17179057]
11. Singh H, Penfold RB, DeCoster C, Kaita L, Proulx C, Taylor G, et al. Colonoscopy and its complications across a Canadian regional health authority. Gastrointest Endosc. 2009; 69(3 Pt 2): 665–71. [PubMed: 19251007]
12. Warren JL, Klabunde CN, Mariotto AB, Meekins A, Topor M, Brown ML, et al. Adverse events after outpatient colonoscopy in the Medicare population. Ann Intern Med. 2009; 150:849–57. [PubMed: 19528563]
13. Ko CW, Riffle S, Michaels L, Morris C, Holub J, Shapiro JA, et al. Serious complications within 30 days of screening and surveillance colonoscopy are uncommon. Clin Gastroenterol Hepatol. 2010; 8(2):166–73. [PubMed: 19850154]
14. Shih YC, Zhao L, Elting LS. Does Medicare coverage of colonoscopy reduce racial/ethnic disparities in cancer screening among the elderly? Health Aff (Millwood). 2006; 25(4):1153–62. [PubMed: 16835198]
15. Winawer S, Fletcher R, Rex D, Bond J, Burt R, Ferrucci J, et al. Colorectal cancer screening and surveillance: clinical guidelines and rationale-Update based on new evidence. Gastroenterology. 2003; 124(2):544–60. [PubMed: 12557158]
16. Rabeneck L, Paszat LF, Hilsden RJ, Saskin R, Leddin D, Grunfeld E, et al. Bleeding and perforation after outpatient colonoscopy and their risk factors in usual clinical practice. Gastroenterology. 2008; 135(6):1899–1906. 1906.e1. [PubMed: 18938166]
17. Cheon JH, Kim WH. Recent advances of endoscopy in inflammatory bowel diseases. Gut and Liver. 2007; 1(2):118–25. [PubMed: 20485627]
18. Greenstein AJ, Sachar DB, Smith H, Janowitz HD, Aufses AH Jr. A comparison of cancer risk in Crohn's disease and ulcerative colitis. Cancer. 1981; 48(12):2742–5. [PubMed: 7306930]
19. Konda A, Duffy MC. Surveillance of patients at increased risk of colon cancer: inflammatory bowel disease and other conditions. Gastroenterol Clin North Am. 2008; 37(1):191–213. viii. [PubMed: 18313546]
20. Klabunde CN, Potosky AL, Legler JM, Warren JL. Development of a comorbidity index using physician claims data. J Clin Epidemiol. 2000; 53(12):1258–67. [PubMed: 11146273]
21. Rutter CM, Yu O, Miglioretti DL. A hierarchical non-homogenous Poisson model for meta-analysis of adenoma counts. Stat Med. 2007; 26(1):98–109. [PubMed: 16372387]
22. Sharma VK, Nguyen CC, Crowell MD, Lieberman DA, de Garmo P, Fleischer DE. A national study of cardiopulmonary unplanned events after GI endoscopy. Gastrointest Endosc. 2007; 66(1): 27–34. [PubMed: 17591470]


## Appendix: Exclusion Criteria

Here we describe specific codes found in automated data that we used to exclude colonoscopies from our sample. These are based on ICD-9 diagnosis, procedure, and v-codes, and CPT-4 and HCPCS procedure codes. First, we excluded colonoscopies based on

procedure codes. We excluded therapeutic and high-risk colonoscopies. HCPCS code G0105 and CPT codes 45337, 45355, 45379, 45382, 45386, 45387, 45391, 45392. We also excluded colonoscopies through a colotomy: CPT codes 45355, 44388, 44390, 44391, 44392, 44393, 44394, 44397, 44489.

Next, we excluded colonoscopies that may have been symptom-drive, based on visit diagnosis in the 6 months prior to the index colonoscopy, including abdominal pain (ICD-9 789.X), gastrointestinal bleeding (ICD-9 codes 45.43, 285.1, 562.13, 578.1, 558.9, 578.9, 998.1 – 998.13), diarrhea (ICD-9 codes: infectious: 009.X, NOS 787.91), anemia (iron deficiency: ICD-9 280.X, screening for iron deficiency anemia ICD-9 V78.0, or unspecified anemia ICD-9 285.9), drop in hematocrit (ICD-9 790.01), fecal incontinence (ICD-9 787.6), protozoal intestinal disease (ICD-9 007.X), functional digestive disorder (ICD-9 564.X), vascular insufficiency of the intestine (ICD-9 557.X), diverticulitis of the intestine with or without hemorrhage (ICD-9 562.11,562.13), other gastroenteritis or colitis (ICD-9 558, 558.1–558.3, 558.9), anal fissure or fistula (ICD-9 565.X), intestinal obstruction (ICD-9 560.X), intestinal malabsorption (ICD-9 579.X), and other disorders of the intestine (ICD-9 569.X).

Third, we excluded colonoscopies in individuals who had an upper endoscopy in the seven days before colonoscopy, based on ICD-9 codes (45.11, 45.12, 45.13, 45.16), CPT codes (43200 – 44386), and an HCPCS code indicating referral for upper endoscopy (3132F). We also excluded colonoscopies in individuals with abdominal imaging in the 90 days prior to colonoscopy:

| | |
|---|---|
| ICD-9 codes: | 87.5X, 87.6X, 87.7X, 87.8X, 87.91, 87.92, 87.94, 87.99, 88.0 – 88.03, 88.09, 88.1X, 88.7, 88.74 – 88.76, 88.79, 88.9X, 92.0X |
| CPT codes: | 72170, 72190, 72192 – 72194, 73540, 74000 – 74170, 74181 – 74183, 74190, 74220, 74240, 74241, 74245 – 74330, 74363, 74400 – 74471, 74720 – 74741, 74760, 75980 –75983, 76010, 76081, 76380, 76700 – 76705, 76770, 76775, 76778, 76830, 76831, 76855 – 76873, 76925, 76948, 78185, 78186, 78201 – 78232, 78240, 78258 – 78264, 78270 – 78272, 78276, 78278, 78280, 78283, 78290, 78291, 78298, 78299, 78700 –78799, |
| HCPCS codes: | Q9954, S8037, G0163 – G0165, G0213 – G0215, G0226 – G0228, G0231 |

We excluded individuals in whom colonoscopy may be used to guide treatment, including those with a prior diagnosis of ulcerative colitis (ICD-9 556.X), regional enteritis (Crohn's disease, ICD-9 555.X), vascular insufficiency of the intestine (ICD-9 557.X), neurogenic bowel (ICD-9 564.81), and other and unspecified noninfectious gastroenteritis and colitis (ICD-9 558.1 – 558.3, 558.9). We also excluded individuals who underwent colonoscopies after colonic resection (ICD-9 45.7X, 45.8; CPT 44202 – 44212). We excluded individuals who were not eligible for usual screening based on personal or family history of malignant neoplasms in the gastrointestinal tract (ICD-9 V10.05, V16.0, V18.51, V12.72), benign neoplasm (polyp) of the colon (ICD-9 211.3) or rectum or anal canal (ICD-9 211.4) or neoplasm uncertain behavior stomach, intestines, or rectum (ICD-9 235.2). While we relied primarily on SEER data to exclude individuals with prior cancer diagnoses, we also used electronic medial record data to exclude individuals with colon or rectal cancer based on ICD-9 (153.x, 154.X, 197.5) and HCPCS (G0213, G0214, G0215, G0231) codes.

Finally, we excluded individuals with an internal defibrillator who may be at increased risk following colonoscopy, particularly if they undergo electrocautery (ICD-9: 37.94 – 37.99, CPT: 33215 – 33223, 33249, 93745, HCPCS: C1721,C1722,C1899, ICD-9: V53.32)

**Table 1**

Characteristics of Patients Identified as Undergoing Screening or Follow-Up Colonoscopy

| | Any Colonoscopy | Indication | | Polypectomy | |
|---|---|---|---|---|---|
| | | Screening | Follow-Up | No | Yes |
| **Total** | 43,456 | 38,472 | 4,984 | 22,885 | 20,571 |
| **Female** | 22,081 (51%) | 19,835 (52%) | 2,426 (45%) | 12,830 (56%) | 9,251 (45%) |
| **Age** | | | | | |
| 40–49 | 2,642 (6.1%) | 2,450 (6.4%) | 192 (3.9%) | 1,507 (6.6%) | 1,135 (5.5%) |
| 50–64 | 31,262 (72%) | 28,565 (74%) | 2,697 (54%) | 16,722 (73%) | 14,540 (71%) |
| 65–74 | 7,213 (17%) | 5,804 (15%) | 1,409 (28%) | 3,485 (15%) | 3,728 (18%) |
| 75–85 | 2,339 (5.4%) | 1,653 (4.3%) | 686 (14%) | 1,171 (5.1%) | 1,158 (5.7%) |
| **Year** | | | | | |
| 1994–1997 | 2,093 (4.8%) | 864 (2.3%) | 1,229 (25%) | 1,085 (4.7%) | 1,008 (4.9%) |
| 1998–2001 | 3,210 (7.4%) | 2,033 (5.3%) | 1,177 (24%) | 1,647 (7.2%) | 1,563 (7.6%) |
| 2002–2005 | 13,167 (30%) | 11,762 (31%) | 1,405 (28%) | 7,352 (32%) | 5,815 (28%) |
| 2006–2009 | 24,986 (58%) | 23,813 (62%) | 1,173 (24%) | 12,801 (56%) | 12,185 (59%) |
| **Klabunde Score** | | | | | |
| 0 | 32,360 (80%) | 28,767 (80%) | 3,593 (76%) | 17,414 (81%) | 14,946 (78%) |
| 1 | 6,317 (15%) | 5,480 (15%) | 837 (18%) | 3,135 (15%) | 3,182 (17%) |
| 2 | 1,380 (3.4%) | 1,153 (3.2%) | 227 (4.8%) | 639 (3.0%) | 741 (3.9%) |
| 3+ | 558 (1.4%) | 468 (1.3%) | 90 (1.9%) | 259 (1.2%) | 299 (1.6%) |

**Table 2**

Adverse Events 30 Days After Outpatient Screening or Follow-Up Colonoscopy*

| | Any Colonoscopy | Indication | | Polypectomy | |
|---|---|---|---|---|---|
| | | Screening | Follow-Up | No | Yes |
| Number of exams | 43,456 | 38,472 | 4,984 | 22,855 | 20,571 |
| Died | 15 (0.03%) | 12 (0.03%) | 3 (0.06%) | 5 (0.02%) | 10 (0.05%) |
| Perforation | 21 (0.05%) | 15 (0.04%) | 6 (0.12%) | 7 (0.03%) | 14 (0.07%) |
| Hemorrhage | 122 (0.28%) | 103 (0.27%) | 19 (0.38%) | 19 (0.08%) | 103 (0.50%) |
| Diverticulitis | 82 (0.19%) | 71 (0.18%) | 11 (0.22%) | 41 (0.18%) | 41 (0.20%) |
| Abdominal pain | 1,126 (2.59%) | 1,016 (2.64%) | 110 (2.21%) | 600 (2.62%) | 526 (2.56%) |
| Any serious adverse event** | 215 (0.49%) | 181 (0.47%) | 34 (0.68%) | 62 (0.27%) | 153 (0.74%) |
| Hospitalizations | 508 (1.17%) | 428 (1.11%) | 80 (1.61%) | 214 (0.94%) | 294 (1.43%) |
| Emergency Department or Urgent Care Visit | 1,019 (2.34%) | 869 (2.26%) | 150 (3.01%) | 510 (2.23%) | 509 (2.47%) |

*Adverse event counts do not represent unique individuals; 6,953 individuals (16%) had multiple events.

**Serious adverse events include perforation, hemorrhage, or diverticulitis

## Table 3

Adverse Events 30 Days After Outpatient Screening or Follow-up Colonoscopy by Age*

| | Age in Years | | | |
|---|---|---|---|---|
| | **40–49** | **50–64** | **65–74** | **75–85** |
| Number of exams | 2,642 | 31,262 | 7,213 | 2,339 |
| Died | 0 (0.00%) | 9 (0.03%) | 3 (0.04%) | 3 (0.13%) |
| Perforation | 0 (0.00%) | 10 (0.03%) | 7 (0.10%) | 4 (0.17%) |
| Hemorrhage | 6 (0.23%) | 66 (0.21%) | 31 (0.43%) | 19 (0.81%) |
| Diverticulitis | 6 (0.23%) | 42 (0.13%) | 24 (0.33%) | 10 (0.43%) |
| Abdominal pain | 169 (6.4%) | 693 (2.2%) | 182 (2.5%) | 82 (3.5%) |
| Any serious adverse event** | 11 (0.42%) | 116 (0.37%) | 57 (0.79%) | 31 (1.3%) |
| Hospitalizations | 28 (1.1%) | 277 (0.89%) | 141 (2.0%) | 62 (2.7%) |
| Emergency Department or Urgent Care Visit | 77 (2.9%) | 684 (2.2%) | 177 (2.5%) | 81 (3.5%) |

*Adverse event counts do not represent unique individuals; 6,953 individuals (16%) had multiple events.

**Serious adverse include perforation, hemorrhage, or diverticulitis