

Adverse Events After Outpatient Colonoscopy in the Medicare Population

Joan L. Warren, PhD; Carrie N. Klabunde, PhD; Angela B. Mariotto, PhD; Angela Meekins, BS; Marie Topor, BS; Martin L. Brown, PhD; and David F. Ransohoff, MD

Background: Although use of colonoscopy has increased substantially among elderly Medicare beneficiaries, no one has described colonoscopy-related adverse events in a representative sample of Medicare patients.

Objective: To determine risk for adverse events after outpatient colonoscopy in elderly patients.

Design: Population-based, matched cohort study.

Setting: Surveillance, Epidemiology, and End Results cancer registry areas.

Patients: Random 5% sample of Medicare beneficiaries, age 66 to 95 years, who underwent outpatient colonoscopy between 1 July 2001 and 31 October 2005 ($n = 53\,220$), matched with beneficiaries who did not have colonoscopy.

Measurements: Medicare claims were used to measure the rate of serious gastrointestinal events (bleeding and perforation), other gastrointestinal events, and cardiovascular events resulting in a hospitalization or emergency department visit within 30 days after colonoscopy compared with matched beneficiaries who did not have colonoscopy. Logistic regression was used to estimate adjusted predictive risks for adverse events and to assess whether these events varied by age, comorbid conditions, or type of colonoscopy.

Results: Persons undergoing colonoscopy had a higher risk for adverse gastrointestinal events than their matched group. Rates of adverse events after colonoscopy increased with age. Patients having polypectomy had higher risk for all adverse events compared with their matched group and with the screening and diagnostic colonoscopy groups. Comorbid conditions increased the risk for adverse events. Patients with a history of stroke, chronic obstructive pulmonary disease, atrial fibrillation, or congestive heart failure had significantly higher risk for serious gastrointestinal events.

Limitation: The analysis relied on the diagnosis and procedure codes recorded on the Medicare claims.

Conclusion: Risks for adverse events after outpatient colonoscopy among elderly Medicare beneficiaries were low; however, they increased with age with specific comorbid conditions and depending on whether polypectomy was done. These data may inform decisions on whether to perform colonoscopy in persons of advanced age or those with comorbid conditions.

Primary Funding Source: None.

Ann Intern Med. 2009;150:849-857.

For author affiliations, see end of text.

www.annals.org

Since 1998, Medicare has covered colorectal cancer screening of average-risk beneficiaries age 50 years or older with fecal occult blood testing, sigmoidoscopy, and double-contrast barium enema. In July 2001, Medicare expanded this coverage to include screening colonoscopy. Use of colorectal cancer screening by Medicare beneficiaries has increased subsequent to the coverage (1). However, the increased use is largely attributable to colonoscopy (2).

Primary care physicians play an important role in colorectal cancer screening. Physician recommendation is 1 of the strongest predictors of whether patients are screened (3–5). Guidelines suggest that providers and patients should discuss the advantages and disadvantages of the different screening tests (6). However, studies show that primary care physicians' discussions with patients about colorectal cancer screening lack key information, especially an explanation of procedure risks (7, 8).

Of the 4 types of colorectal cancer screening tests recommended by major expert groups (9–11), colonoscopy is the most invasive and has the greatest risk for complications. Yet, studies documenting adverse events after colonoscopy are limited because they have included persons of all ages and, in some studies, adverse events have not been the main focus of the analysis (12–25). Despite the increasing use of colonoscopy in elderly persons, no

population-based studies have examined the risks of colonoscopy in elderly persons. Recent guidelines note that complications of colonoscopy by age cannot be estimated because of the limitations of currently published studies (26). We address this gap in the literature by determining risks for adverse events after outpatient colonoscopy in elderly persons. We also assess whether particular patient subgroups are at increased risk for adverse events. Information about the risks of colonoscopy can assist primary care physicians with recommendations about the most appropriate method of colorectal cancer screening for older patients.

See also:

Print

Editors' Notes 850
Summary for Patients I-32

Web-Only

Appendix Table
Conversion of graphics into slides

Context

The complication rates of colonoscopy are well established in middle-age patients but are not known for elderly persons.

Contribution

The authors measured 30-day rates of cardiac and gastrointestinal events in a random sample of 53 220 Medicare beneficiaries who had outpatient colonoscopy and in a matched set of beneficiaries who did not. Rates were higher in colonoscopy patients, with advancing age and preexisting comorbid conditions (especially diabetes, heart failure, atrial fibrillation, stroke, and chronic obstructive pulmonary disease), and after polypectomy.

Caution

The study used diagnostic billing codes rather than medical record review.

Implication

Advancing age and an increasing number of comorbid conditions are reasons to be cautious about recommending colonoscopy.

—The Editors

METHODS**Overview**

We used Medicare data to identify a cohort of beneficiaries who underwent colonoscopy between 1 July 2001 and 31 October 2005. Medicare claims are longitudinal, allowing us to determine adverse events resulting in emergency department or hospital use within 30 days after colonoscopy. Claims were also used to assess the presence of selected health conditions in the year before colonoscopy. In addition, we used the Medicare data to identify a comparison group of beneficiaries who had not undergone colonoscopy. The comparison group enabled us to estimate the baseline risk for adverse events in the elderly population.

Data Sources

Data for this analysis came from a random 5% sample of Medicare beneficiaries who resided in one of the Surveillance, Epidemiology, and End Results cancer registry areas (27), which represent about 25% of the U.S. population. For these beneficiaries, we reviewed their physician, outpatient, emergency department, and hospital claims. Diagnoses and procedures are reported on Medicare claims by using Healthcare Common Procedure Coding System (28, 29) and International Classification of Disease, Ninth Edition, Clinical Modification (ICD-9-CM), codes (30). The **Appendix Table** (available at www.annals.org) lists the codes used to identify all diagnoses and procedures in this analysis.

Defining the Cohort and Colonoscopies

We identified 118 002 colonoscopies from Medicare physician bills. The analysis included colonoscopies performed in the outpatient setting. We excluded procedures that were performed in the inpatient setting ($n = 20\,814$), those coded by the physician as incomplete ($n = 810$), and those done in persons at high risk for perforation. The latter group included persons with a diagnosis of diverticulitis, Crohn disease or ulcerative colitis, or colorectal cancer ($n = 3139$). We limited the cohort to persons age 66 to 95 years at the time of their procedure (8430 persons younger than 66 years were excluded) in order to have 12 months of claims before the colonoscopy that could be reviewed for the presence of comorbid conditions. To ensure complete data for the analysis, we required all patients to have continuous enrollment in Medicare Parts A and B and fee-for-service coverage during the year before their colonoscopy and for 30 days after the procedure (7014 persons were excluded on this basis). The date of the procedure was determined from the physician claim. We also removed from the analysis 4421 patients who had more than 2 colonoscopies during our study period and 812 patients who had 2 colonoscopies less than 60 days apart. Finally, we excluded 12 912 persons who had their procedure outside of a SEER area because we did not have complete data for these cases.

We assigned each outpatient colonoscopy to 1 of 3 categories: screening, diagnostic, and procedures with polypectomy. We used procedure codes on the colonoscopy claim to classify the type of procedure. In addition, procedures with a pathology bill for examination of a colorectal polyp within 7 days of the procedure were classified as polypectomies. Per Medicare coding policy, colonoscopies that were initiated as screening or diagnostic procedures are coded as polypectomy if polyps were removed during the procedure. Therefore, our polypectomy group comprised persons who underwent colonoscopy for screening and diagnostic reasons. Each procedure needed to be accompanied by an ICD-9-CM diagnosis code that identified the reason for the procedure. We used these codes to determine why the colonoscopy was performed.

We assessed adverse events after outpatient colonoscopy. We used a matched cohort design, identifying a comparable group of Medicare beneficiaries who had not undergone colonoscopy from 1 July 2001 to 31 October 2005. For ease of reference, we refer to persons undergoing colonoscopy as the “colonoscopy group” and their matched cohort as the “matched group.” We used the matched group to determine whether the risk for adverse events observed in the group undergoing colonoscopy was higher than that in the general Medicare population. All potential matches were randomly assigned a “pseudo-date” of procedure that corresponded to the procedure date for the case patients, as has been done in other analyses (31). Characteristics used in matching each person in the colonoscopy group

Table 1. Characteristics of Medicare Beneficiaries Undergoing Outpatient Colonoscopy and Matched Case Patients

Characteristic	Any Colonoscopy (n = 53 220)		Screening Procedures (n = 5349)		Diagnostic Procedures (n = 17 883)		Colonoscopy With Polypectomy (n = 29 988)	
	Colonoscopy Group, n (%)	Matched Group, n (%)	Colonoscopy Group, n (%)	Matched Group, n (%)	Colonoscopy Group, n (%)	Matched Group, n (%)	Colonoscopy Group, n (%)	Matched Group, n (%)
Age at procedure								
66–69 y	12 942 (24.3)	12 986 (24.4)	1629 (30.5)	1657 (31.0)	4068 (22.7)	4085 (22.8)	7245 (24.2)	7244 (24.2)
70–74 y	16 606 (31.2)	16 548 (31.1)	1828 (34.2)	1799 (33.6)	5422 (30.3)	5430 (30.4)	9356 (31.2)	9319 (31.1)
75–79 y	13 289 (25.0)	13 295 (25.0)	1139 (21.3)	1137 (21.3)	4613 (25.8)	4597 (25.7)	7537 (25.1)	7561 (25.2)
80–84 y	7453 (14.0)	7441 (14.0)	593 (11.1)	600 (11.2)	2683 (15.0)	2672 (14.9)	4177 (13.9)	4169 (13.9)
≥85 y	2930 (5.5)	2950 (5.5)	160 (3.0)	156 (2.9)	1097 (6.1)	1099 (6.1)	1673 (5.6)	1695 (5.7)
Race								
White	45 701 (85.9)	45 701 (85.9)	4670 (87.3)	4670 (87.3)	15 388 (86.0)	15 388 (86.0)	25 643 (85.5)	25 643 (85.5)
Black	3327 (6.3)	3327 (6.3)	321 (6.0)	321 (6.0)	1258 (7.0)	1258 (7.0)	1748 (5.8)	1748 (5.8)
Other	4192 (7.9)	4192 (7.9)	358 (6.7)	358 (6.7)	1237 (6.9)	1237 (6.9)	2597 (8.7)	2597 (8.7)
Sex								
Male	22 174 (41.7)	22 174 (41.7)	2033 (38.0)	2033 (38.0)	6681 (37.4)	6681 (37.4)	13 460 (44.9)	13 460 (44.9)
Female	31 046 (58.3)	31 046 (58.3)	3316 (62.0)	3316 (62.0)	11 202 (62.6)	11 202 (62.6)	16 528 (55.1)	16 528 (55.1)
Comorbid condition								
Stroke	2453 (4.6)	2902 (5.5)	176 (3.3)	198 (3.7)	871 (4.9)	943 (5.3)	1406 (4.7)	1761 (5.9)
COPD	3791 (7.1)	4167 (7.8)	213 (4.0)	321 (6.0)	1137 (6.4)	1329 (7.4)	2441 (8.1)	2517 (8.4)
CHF	2844 (5.3)	3530 (6.6)	165 (3.1)	234 (4.4)	975 (5.5)	1188 (6.6)	1704 (5.7)	2108 (7.0)
Atrial fibrillation or flutter	3638 (6.8)	3318 (6.2)	273 (5.1)	236 (4.4)	1220 (6.8)	1143 (6.4)	2145 (7.2)	1939 (6.5)
Diabetes	8961 (16.8)	8809 (16.6)	738 (13.8)	651 (12.2)	2925 (16.4)	2921 (16.3)	5298 (17.7)	5237 (17.5)

CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease.

with a person in the match group were birth year, procedure year, race, sex, state or county of residence, and comorbidity score. We excluded colonoscopies with no corresponding beneficiary in the match group ($n = 473$). Our final cohort consisted of 53 220 colonoscopies.

Adverse Events

We identified all adverse events occurring within 30 days after outpatient colonoscopy that were severe enough to require an emergency department visit or hospitalization. For the matched group, we identified all adverse events within 30 days of the pseudo-date of procedure. The 30-day risk for adverse events requiring an emergency department visit or hospitalization was calculated per 1000 procedures. Adverse events were classified into 3 groups: serious gastrointestinal events (perforation, gastrointestinal bleeding, or the administration of blood transfusions), other gastrointestinal events (paralytic ileus, nausea, vomiting and dehydration, abdominal pain), and cardiovascular events (myocardial infarction or angina; arrhythmias; congestive heart failure [CHF]; cardiac or respiratory arrest; or syncope, hypotension, or shock). We did not include death as a complication because the number of deaths was too small to provide statistical power (53 of 53 200 colonoscopies) and the cause of death cannot be determined from claims data.

Measurements

Variables included as covariates in the models were patient age group, race, sex, and state and county of residence, all of which are reported in the Medicare data. Information about whether a patient resided in an urban or rural location was based on a link to the Area Resource File

(32). We used U.S. Census data associated with the ZIP code of the patient's residence to measure his or her socioeconomic status. These proxy variables included information at that ZIP code level about the median household income, percentage of persons with a college education, and percentage of households with foreign-born persons. Comorbid conditions were identified from diagnoses reported on physician and hospital claims in the year before the procedure date by using Romano and colleagues' modification of the Charlson comorbidity index (33, 34). Although a summary measure of comorbidity is useful to ensure comparability between the colonoscopy and matched groups, it does not provide information about the risk for adverse events for persons with specific health conditions. We therefore identified 5 comorbid conditions that are common in elderly persons: diabetes, stroke (cerebrovascular accidents and transient ischemic attacks), chronic obstructive pulmonary disease (COPD), atrial fibrillation, and CHF.

We obtained our data primarily from Medicare claims. We had no missing information for patients' age, race, sex, or residence. Information about patients' past health status was determined from diagnoses recorded on Medicare claims. It is not possible to assess the extent to which information on health status was missing. Missing data about socioeconomic status within a ZIP code varied by measure but in no case exceeded 5%.

Statistical Analysis

We calculated absolute unadjusted risks for adverse events (Table 1) by counting the number of specific ad-

Table 2. Diagnosis Provided for Outpatient Colonoscopy*

Diagnosis Provided for Procedure	Screening Procedures (n = 5349), %	Diagnostic Procedures (n = 17 883), %	Colonoscopy With Polypectomy (n = 29 988), %
Screening	55.6	1.0	1.3
Family or personal history of malignant neoplasm	30.2	5.1	1.5
Diverticulosis of colon	3.4	45.2	8.9
Blood in stool or gastrointestinal bleeding	1.7	19.4	5.7
Functional digestive disorders (constipation, diarrhea, or change in bowel habits)	1.7	11.3	5.0
Hemorrhoids	1.9	1.8	0.5
Benign neoplasm of colon and rectum	0.4	4.4	64.8
Anemia	0.3	3.6	1.6
Other	4.8	8.2	10.9

* Diagnoses are based on International Classification of Disease, Ninth Revision, Clinical Modification, codes; procedures are identified from Healthcare Common Procedure Coding System codes.

verse events within 30 days of the procedure, not controlling for covariates. For unadjusted risk for adverse events, we used chi-square analysis to determine whether the risk for adverse events differed significantly between the colonoscopy group and the matched group.

We conducted multivariate logistic regression analyses to investigate the risk for adverse events, controlling for covariates. We considered 3 separate models that had these dependent variables: serious gastrointestinal events, other gastrointestinal events, and cardiovascular events. We ran these models with the colonoscopy and matched groups combined (n = 106 440). The comparison of the colonoscopy group with the matched group allowed us to assess whether undergoing colonoscopy resulted in a greater risk for adverse events relative to what normally occurs in the elderly population. We present the logistic regression re-

sults as predictive marginal risks. These adjusted risks represent the estimated average response associated with the respective intervention or risk factor adjusting for other covariates (35). We calculated the adjusted risk for an intervention or risk factor by averaging the individual predicted risks, assuming that all individuals in the standard population with respective covariates had the intervention or risk factor. Adjusted risks are displayed as 30-day risks per 1000 colonoscopies. We used SAS, version 9.1.3 (SAS Institute, Cary, North Carolina), for all statistical analyses.

Role of the Funding Source

This work was performed by federal researchers at the National Cancer Institute in consultation with an outside clinician. Our study received no external funding.

Table 3. Unadjusted Risk per 1000 Persons for Specific Adverse Events Within 30 Days of Colonoscopy*

Adverse Event	All Procedures (n = 53 220)					Screening Procedures (n = 5349)				
	Colonoscopy Group		Matched Group		P Value	Colonoscopy Group		Matched Group		P Value
	Events, n	Risk	Events, n	Risk		Events, n	Risk	Events, n	Risk	
Serious GI events	368	6.9	97	1.8	<0.001	13	2.4	8	1.5	0.28
Perforations	33	0.6	6	0.1	<0.001	3	0.6	1	0.2	0.31
GI bleeding or transfusions	340	6.4	95	1.8	<0.001	11	2.1	7	1.3	0.35
Other GI events	639	12.0	334	6.3	<0.001	31	5.8	28	5.2	0.70
Paralytic ileus	172	3.2	37	0.7	<0.001	6	1.1	3	0.6	0.32
Nausea and vomiting, dehydration	361	6.8	269	5.1	<0.001	18	3.4	23	4.3	0.44
Abdominal pain	176	3.3	48	0.9	<0.001	11	2.1	5	0.9	0.134
Cardiovascular events	1030	19.4	885	16.6	<0.001	53	9.9	80	15.0	0.019
MI or angina	241	4.5	214	4.0	0.20	13	2.4	18	3.4	0.37
Arrhythmias	543	10.2	423	7.9	<0.001	30	5.6	37	6.9	0.39
Congestive heart failure	305	5.7	374	7.0	<0.001	8	1.5	30	5.6	<0.001
Cardiac or respiratory arrest	115	2.2	118	2.2	0.84	8	1.5	8	1.5	1.00
Syncope, hypotension, or shock	196	3.7	150	2.8	0.013	8	1.5	14	2.6	0.20

GI = gastrointestinal; MI = myocardial infarction.

* Specific types of events may sum to more than the total for the category because patients may have more than 1 type of event. For the matched group, claims from the 30 days after the pseudo-date of procedure were used to identify adverse events.

RESULTS

Medicare Beneficiary and Procedure Characteristics

Of the 53 220 colonoscopies included in our analysis, 10.1% were billed as screening procedures, 33.6% as diagnostic procedures, and 56.3% as procedures involving polypectomy (Table 1). More persons undergoing screening colonoscopy were 66 to 74 years of age (64.7%) than those undergoing diagnostic procedures (53.0%) or colonoscopy with polypectomy (55.4%). Persons undergoing screening procedures also had fewer comorbid conditions than those undergoing diagnostic procedures or colonoscopy with polypectomy. The diagnoses associated with the colonoscopy varied by type of procedure (Table 2): 85.8% of persons having screening procedures had an ICD-9-CM diagnosis for screening or family or personal history of cancer, whereas 45.2% of persons having diagnostic procedures had a diagnosis of diverticulosis and 64.8% of persons having polypectomy procedures had a diagnosis of benign neoplasm of the colon or rectum.

Complication Risks, by Procedure Type and Beneficiary Characteristics

Risk for perforation was similar for all types of colonoscopies: about 0.6 per 1000 procedures (Table 3). Unadjusted risk for gastrointestinal bleeding was more than 4 times higher for the polypectomy group (8.7 per 1000 procedures) than the screening group (2.1 per 1000 procedures). Risk for paralytic ileus was also higher in the polypectomy group (4.8 per 1000 procedures) than in the diagnostic group (1.3 per 1000 procedures) or screening group (1.1 per 1000 procedures). Risk for cardiovascular events was higher in the polypectomy

group (23.4 per 1000 procedures) or diagnostic group (15.4 per 1000 procedures) than in the screening group (9.9 per 1000 procedures). For all types of colonoscopies, the most common cardiovascular event was arrhythmia (10.2 per 1000 procedures).

Table 4 shows the adjusted predictive risk for adverse events with 95% CIs by type of procedure, including persons not having colonoscopy. Compared with persons who did not undergo colonoscopy, the adjusted predictive risk for a serious gastrointestinal event was significantly greater for persons undergoing diagnostic colonoscopy or colonoscopy with polypectomy (risk per 1000 procedures, 1.8 [95% CI, 1.4 to 2.1] for no colonoscopy, 4.2 [CI, 3.3 to 5.2] for diagnostic colonoscopy, and 9.4 [CI, 8.2 to 10.5] for colonoscopy with polypectomy). The polypectomy group was also at significantly greater risk for other gastrointestinal events than the no colonoscopy, screening, and diagnostic groups (risk per 1000 procedures, 13.0 [CI, 11.7 to 14.4] vs. 5.7 [CI, 5.0 to 6.3], 6.5 [CI, 4.2 to 8.9], and 8.9 [CI, 7.5 to 10.3], respectively). The adjusted risk for a cardiovascular event was significantly greater for the polypectomy group than the no colonoscopy, screening, or diagnostic groups (risk per 1000 procedures, 23.8 [CI, 21.6 to 25.1] vs. 15.9 [CI, 14.8 to 16.9], 12.5 [CI, 9.1 to 15.8], and 15.8 [CI, 14.0 to 17.7], respectively).

Table 4 also presents the adjusted risk for adverse events by age and selected comorbid conditions, stratified by intervention, for the colonoscopy group versus the matched group. The risk for adverse events among persons undergoing colonoscopy increased with age (Table 4). Relative to persons age 66 to 69 years, the adjusted predictive risk for adverse gastrointestinal events was significantly

Table 3—Continued

Diagnostic Procedures (n = 17 883)					Colonoscopy With Polypectomy (n = 29 988)				
Colonoscopy Group		Matched Group		P Value	Colonoscopy Group		Matched Group		P Value
Events, n	Risk	Events, n	Risk		Events, n	Risk	Events, n	Risk	
75	4.2	27	1.5	<0.001	280	9.3	62	2.1	<0.001
9	0.5	3	0.2	0.083	21	0.7	2	0.1	<0.001
67	3.7	27	1.5	<0.001	262	8.7	61	2.0	<0.001
176	9.8	120	6.7	<0.001	432	14.4	186	6.2	<0.001
23	1.3	16	0.9	0.25	143	4.8	18	0.6	<0.001
116	6.5	96	5.4	0.164	227	7.6	150	5.0	<0.001
61	3.4	18	1.0	<0.001	104	3.5	25	0.8	<0.001
275	15.4	281	15.7	0.80	702	23.4	524	17.5	<0.001
71	4.0	68	3.8	0.80	157	5.2	128	4.3	0.084
138	7.7	134	7.5	0.81	375	12.5	252	8.4	<0.001
99	5.5	113	6.3	0.33	198	6.6	231	7.7	0.107
32	1.8	37	2.1	0.55	75	2.5	73	2.4	0.87
53	3.0	47	2.6	0.55	135	4.5	89	3.0	0.002

Table 4. Adjusted Risk per 1000 Persons for an Adverse Event Within 30 Days of Outpatient Colonoscopy*

Variable	Risk (95% CI)					
	Serious GI Events		Other GI Events		Cardiovascular Events	
Type of procedure						
No colonoscopy	1.8 (1.4–2.1)		5.7 (5.0–6.3)		15.9 (14.8–16.9)	
Screening	2.8 (1.2–4.3)		6.5 (4.2–8.9)		12.5 (9.1–15.8)	
Diagnostic	4.2 (3.3–5.2)		8.9 (7.5–10.3)		15.8 (14.0–17.7)	
Polypectomy	9.4 (8.2–10.5)		13.0 (11.7–14.4)		23.3 (21.6–25.1)	
	Colonoscopy Group	Matched Group (No Colonoscopy)	Colonoscopy Group	Matched Group (No Colonoscopy)	Colonoscopy Group	Matched Group (No Colonoscopy)
Age group						
66–69 y	5.0 (3.8–6.2)	1.3 (0.9–1.7)	6.9 (5.6–8.2)	3.7 (2.9–4.4)	12.6 (11.0–14.3)	10.7 (9.3–12.2)
70–74 y	5.8 (4.6–6.9)	1.5 (1.1–1.9)	8.7 (7.5–10.0)	4.7 (3.9–5.5)	16.0 (14.4–17.6)	13.6 (12.2–15.0)
75–79 y	7.2 (5.9–8.6)	1.9 (1.4–2.4)	11.7 (10.1–13.3)	6.3 (5.3–7.2)	20.6 (18.6–22.5)	17.5 (15.8–19.2)
80–84 y	8.8 (6.9–10.7)	2.3 (1.7–3.0)	15.9 (13.5–18.3)	8.6 (7.1–10.0)	25.7 (23.0–28.4)	21.9 (19.5–24.2)
≥85 y	12.1 (8.7–15.5)	3.2 (2.2–4.3)	19.0 (15.0–22.9)	10.2 (7.9–12.5)	31.8 (27.4–36.1)	27.1 (23.3–30.8)
Diabetes						
No	6.5 (5.8–7.3)	1.7 (1.4–2.1)	10.0 (9.1–10.9)	5.4 (4.7–6.0)	17.6 (16.4–18.8)	14.9 (13.8–16.0)
Yes	8.2 (6.5–9.8)	2.2 (1.6–2.8)	14.3 (12.2–16.4)	7.7 (6.4–9.0)	25.5 (23.1–28.0)	21.7 (19.5–23.9)
Stroke						
No	6.4 (5.7–7.1)	1.7 (1.3–2.0)	10.3 (9.4–11.2)	5.5 (4.8–6.1)	18.4 (17.2–19.5)	15.4 (14.3–16.5)
Yes	13.5 (9.8–17.2)	3.5 (2.4–4.7)	18.6 (14.7–22.5)	9.9 (7.7–12.1)	30.5 (26.4–34.7)	25.7 (22.3–29.2)
COPD						
No	6.5 (5.8–7.2)	1.7 (1.4–2.1)	10.0 (9.1–10.9)	5.3 (4.7–6.0)	17.6 (16.4–18.7)	14.7 (13.7–15.8)
Yes	9.8 (7.3–12.4)	2.6 (1.8–3.4)	18.7 (15.3–22.0)	10.0 (8.0–11.9)	31.9 (28.3–35.5)	26.9 (23.8–30.0)
Atrial fibrillation						
No	6.4 (5.7–7.1)	1.7 (1.3–2.0)	10.5 (9.6–11.4)	5.6 (5.0–6.3)	16.0 (14.9–17.1)	13.5 (12.5–14.5)
Yes	10.9 (8.1–13.6)	2.9 (2.0–3.8)	13.5 (10.7–16.2)	7.2 (5.6–8.8)	43.3 (38.7–47.9)	36.8 (32.8–40.8)
CHF						
No	6.3 (5.6–7.0)	1.6 (1.3–2.0)	10.0 (9.1–10.9)	5.3 (4.6–5.9)	15.3 (14.3–16.4)	12.4 (11.4–13.3)
Yes	12.8 (9.5–16.1)	3.3 (2.3–4.4)	19.6 (15.8–23.3)	10.4 (8.2–12.5)	52.8 (47.1–58.5)	43.1 (38.5–47.8)

CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; GI = gastrointestinal.
 * Adjusted for race, sex, urban vs. rural location, and socioeconomic status variables (median household income, percentage foreign-born, and percentage college educated). For the matched group, claims from the 30 days after the pseudo-date of procedure were used to identify adverse events.

higher for patients age 80 years or older (risk per 1000 procedures in persons 80 to 84 years of age vs. those 66 to 69 years of age: 8.8 [CI, 6.9 to 10.7] vs. 5.0 [CI, 3.8 to 6.2] for serious gastrointestinal events and 15.9 [CI, 13.5 to 18.3] vs. 6.9 [CI, 5.6 to 8.2] for other gastrointestinal events). Persons in the colonoscopy group were significantly more likely than their age-equivalent matched group to have adverse gastrointestinal events. The risk for adverse cardiovascular events increased with age among persons undergoing colonoscopy, but these rates did not significantly differ from those in the age-equivalent matched group.

Comorbid conditions were associated with an increased risk for adverse gastrointestinal events after colonoscopy. Compared with persons with no history of comorbid conditions, persons undergoing colonoscopy who had a history of stroke, COPD, atrial fibrillation, or CHF had a significantly higher risk for serious gastrointestinal events (adjusted risk per 1000 procedures, 13.5 [CI, 9.8 to 17.2] for those with stroke vs. 6.4 [CI, 5.7 to 7.1] for those without stroke, 9.8 [CI, 7.3 to 12.4] for those with COPD vs. 6.5 [CI, 5.8 to 7.2] for those without COPD, 10.9 [CI, 8.1 to 13.6] for those with atrial fibrillation vs. 6.4 [CI, 5.7 to 7.1] for those without atrial fibrillation, and 12.8 [CI, 9.5 to 16.1] for those with

CHF vs. 6.3 [CI, 5.3 to 7.0] for those without CHF). The risk for other gastrointestinal events among the colonoscopy group was higher for persons with diabetes, stroke, COPD, and CHF (adjusted risk per 1000 procedures, 14.3 [CI, 12.2 to 16.4] for those with diabetes vs. 10.0 [CI, 9.1 to 10.9] for those without diabetes, 18.6 [CI, 14.7 to 22.5] for those with stroke vs. 10.3 [CI, 9.4 to 11.2] for those without stroke, 18.7 [CI, 15.3 to 22.0] for those with COPD vs. 10.0 [CI, 9.1 to 10.9] for those without COPD, and 19.6 [CI, 15.8 to 23.3] for those with CHF vs. 10.0 [CI, 9.1 to 10.9] for those without CHF).

Patients undergoing colonoscopy who had any of the selected comorbid conditions were at increased risk for an adverse cardiovascular event compared with patients undergoing colonoscopy who did not have these conditions. However, the rates of adverse cardiovascular events were similar for patients with the selected comorbid conditions in the colonoscopy group and matched group.

DISCUSSION

The increased use of colonoscopy has heightened interest in the risk of the procedure relative to its benefit. We searched MEDLINE and ClinicalTrials.gov for English-

language studies of adverse events after colonoscopy published through December 2008. Although other studies have reported adverse events after colonoscopy (16–25), we believe that ours is the first population-based analysis to assess adverse events after colonoscopy exclusively in elderly persons. An ongoing observational study at a Veterans Affairs hospital to assess the yield and safety of colonoscopy in patients older than 80 years ended accrual in December 2008 (36).

Bowel perforation is frequently cited as the most serious risk associated with colonoscopy. The unadjusted risk for perforation in our analysis—0.6 per 1000 procedures—is similar to that observed in other studies (14, 18, 19, 22, 25). One study of Medicare beneficiaries undergoing colorectal endoscopy from 1991 to 1998 reported a perforation risk after colonoscopy of 1.96 per 1000 procedures, more than 3 times what we observed (20). However, this earlier study was not restricted to outpatient procedures and was from a time when colonoscopies were performed less frequently, possibly resulting in a higher risk for perforations from less experienced endoscopists. For persons in our study, the unadjusted risk for gastrointestinal bleeding after polypectomy, 8.7 per 1000 procedures, is within the range reported by others: 2.2 per 1000 procedures (14) to 11.3 per 1000 procedures (16). Our unadjusted risk for cardiovascular adverse events, 19.4 per 1000 procedures, is similar to the risk of 20.0 per 1000 procedures reported by the Clinical Outcomes Research Initiative (37).

Although the overall risk for adverse events after colonoscopy is low, we found that the risk for an adverse event increased with age. Persons undergoing colonoscopy at age 75 years or older were at increased risk for other gastrointestinal adverse events. The risk for serious gastrointestinal adverse events was 75% higher for persons age 80 to 84 years compared with persons age 66 to 69 years. Although the risk for adverse cardiovascular events increased with age among persons undergoing colonoscopy, the rate of events in the colonoscopy group did not significantly differ from that in the age-equivalent matched group, suggesting that the events were more related to age than colonoscopy.

Considerable debate has taken place over establishing an upper age limit for screening colonoscopy (12, 15, 38–40). The U.S. Preventive Services Task Force recently assessed the benefits of colorectal cancer screening relative to harms (4), concluding that with the competing causes of mortality that occur in elderly persons, the benefit of colorectal cancer screening will decrease with advancing age. Currently, the U.S. Preventive Services Task Force does not recommend any type of colorectal screening for persons age 75 to 85 years and recommends against screening in persons age 85 years or older. Our findings support these recommendations and provide additional detail about various subgroups, based on comorbid conditions

and type of procedure, in which the risks of colonoscopy might outweigh benefits.

We also found that risk for adverse events, especially for polypectomy procedures, was substantially increased for individuals with certain comorbid conditions—diabetes, stroke, CHF, COPD, or atrial fibrillation. The increased risk for complications in persons with these conditions may be related to the preparation, sedation, or the procedure itself. Certain preparations, such as sodium phosphate, can increase the likelihood of electrolyte imbalances, especially in elderly persons (41, 42). In addition, persons taking angiotensin-converting enzyme inhibitors, angiotensin-receptor blockers, diuretics, and nonsteroidal anti-inflammatory drugs—all of which are commonly used in elderly persons—may have more adverse events related to the bowel preparation for colonoscopy (43).

A previous study of elderly persons assessed life expectancy by level of patient comorbidity at the time of a colon cancer diagnosis and showed a substantial decrease in life expectancy for patients with 3 or more chronic conditions. The authors concluded that a heavy burden of chronic diseases is 1 reason to stop colorectal cancer screening in older persons, because the benefit of screening is marginal at best (44). Our finding of increased 30-day adverse events for persons with significant comorbid conditions, in tandem with this previous work (15), underscores the importance of considering the patient's age and comorbid conditions when evaluating the need for colonoscopy.

Our study has several strengths. We used a large population-based cohort of 53 220 colonoscopies and Medicare claims to longitudinally track risks for hospitalization and emergency department use within 30 days of the procedure. This provided more complete information than could be obtained from the telephone follow-up used in other studies (14, 17). The inclusion of a matched cohort group allowed us to evaluate both gastrointestinal and cardiovascular events, determining their risk in the colonoscopy group beyond what occurs routinely in the elderly population.

Our analysis also has limitations. We relied on ICD-9-CM and Healthcare Common Procedure Coding System codes to identify procedures and adverse events. Diagnoses on Medicare claims for conditions and selected adverse events have been found to have high probability of identifying the condition, although the sensitivity of the claims varies by condition (45). Earlier studies comparing procedures reported in Medicare claims with those reported in physician office records have shown the claims to have high sensitivity and high probability that the identified conditions were truly the condition (46–48). However, we could not always determine the reason for colonoscopy (for example, screening intent or history of polyp). For our purposes, however, those reasons would probably not be related to the outcomes of colonoscopy. Medicare claims have no information about the quality of the preparation, type of sedation, duration of the procedure, or depth of

insertion into the bowel. Our risks for adverse events may underestimate the true risk for events, although we have no reason to believe that any underestimate would vary by type of colonoscopy. It could also be that compared with the matched group, persons in the colonoscopy group were more likely to seek care for an adverse event because they were counseled to seek medical attention if symptoms occurred after their procedure.

In conclusion, our study fills an important gap in the literature by documenting adverse events after outpatient colonoscopy in elderly persons. The risk for adverse events after outpatient colonoscopy among elderly Medicare beneficiaries is strongly related to the type of procedure performed, patient age, and comorbid conditions. In particular, elderly patients with specific, common comorbid conditions are at greater risk for adverse events. Our findings should contribute to the ongoing clinical debate about use of screening colonoscopy among persons with limited life expectancy because of age or comorbid conditions. Clinicians should incorporate these data into their discussions with patients about the risks associated with colonoscopy. Finally, our findings should aid clinicians in making age- and health status–appropriate recommendations to elderly patients for colorectal cancer screening, especially given the availability of Medicare coverage for alternative colorectal cancer screening tests that are less risky than colonoscopy.

From the National Cancer Institute, Bethesda, and Information Management Services, Silver Spring, Maryland, and University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Potential Financial Conflicts of Interest: None disclosed.

Reproducible Research Statement: *Study protocol:* Available from Dr. Warren (e-mail, joan_warren@nih.gov). *Statistical code:* Not available. *Data set:* Available after review for confidentiality at <http://healthservices.cancer.gov/seermedicare/obtain/>.

Requests for Single Reprints: Joan L. Warren, PhD, Health Services and Economics Branch/Applied Research Program, Division of Cancer Control and Population Sciences, National Cancer Institute, Executive Plaza North, Room 4005, 6130 Executive Boulevard, MSC 7344, Bethesda, MD 20892-7344; e-mail, joan_warren@nih.gov.

Current author addresses and author contributions are available at www.annals.org.

References

- 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;25:1153-62.
- Meissner HI, Breen N, Klabunde CN, Vernon SW. Patterns of colorectal cancer screening uptake among men and women in the United States. *Cancer Epidemiol Biomarkers Prev*. 2006;15:389-94. [PMID: 16492934]
- Subramanian S, Klosterman M, Amonkar MM, Hunt TL. Adherence with colorectal cancer screening guidelines: a review. *Prev Med*. 2004;38:536-50. [PMID: 15066356]
- Brawarsky P, Brooks DR, Mucci LA, Wood PA. Effect of physician recommendation and patient adherence on rates of colorectal cancer testing. *Cancer*

- Detect Prev. 2004;28:260-8. [PMID: 15350629]
- Janz NK, Wren PA, Schottenfeld D, Guire KE. Colorectal cancer screening attitudes and behavior: a population-based study. *Prev Med*. 2003;37:627-34. [PMID: 14636796]
- Pignone M, Rich M, Teutsch SM, Berg AO, Lohr KN. Screening for colorectal cancer in adults at average risk: a summary of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med*. 2002;137:132-41. [PMID: 12118972]
- Wolf MS, Baker DW, Makoul G. Physician-patient communication about colorectal cancer screening. *J Gen Intern Med*. 2007;22:1493-9. [PMID: 17851721]
- Canada RE, Turner B. Talking to patients about screening colonoscopy—where conversations fall short. *J Fam Pract*. 2007;56:E1-9. [PMID: 17669281]
- Smith RA, Cokkinides V, von Eschenbach AC, Levin B, Cohen C, Runowicz CD, et al; American Cancer Society. American Cancer Society guidelines for the early detection of cancer. *CA Cancer J Clin*. 2002;52:8-22. [PMID: 11814067]
- U.S. Preventive Services Task Force. Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med*. 2008;149:627-37. [PMID: 18838716]
- Winawer S, Fletcher R, Rex D, Bond J, Burt R, Ferrucci J, et al; Gastrointestinal Consortium Panel. Colorectal cancer screening and surveillance: clinical guidelines and rationale—Update based on new evidence. *Gastroenterology*. 2003;124:544-60. [PMID: 12557158]
- Arora A, Singh P. Colonoscopy in patients 80 years of age and older is safe, with high success rate and diagnostic yield. *Gastrointest Endosc*. 2004;60:408-13. [PMID: 15332032]
- Duncan JE, Sweeney WB, Trudel JL, Madoff RD, Mellgren AF. Colonoscopy in the elderly: low risk, low yield in asymptomatic patients. *Dis Colon Rectum*. 2006;49:646-51. [PMID: 16482421]
- Nelson DB, McQuaid KR, Bond JH, Lieberman DA, Weiss DG, Johnston TK. Procedural success and complications of large-scale screening colonoscopy. *Gastrointest Endosc*. 2002;55:307-14. [PMID: 11868001]
- Sardinha TC, Noguera JJ, Ehrenpreis ED, Zeitman D, Estevez V, Weiss EG, et al. Colonoscopy in octogenarians: a review of 428 cases. *Int J Colorectal Dis*. 1999;14:172-6. [PMID: 10460909]
- Ure T, Dehghan K, Vernava AM 3rd, Longo WE, Andrus CA, Daniel GL. Colonoscopy in the elderly. Low risk, high yield. *Surg Endosc*. 1995;9:505-8. [PMID: 7676371]
- Wexner SD, Forde KA, Sellers G, Geron N, Lopes A, Weiss EG, et al. How well can surgeons perform colonoscopy? *Surg Endosc*. 1998;12:1410-4. [PMID: 9822468]
- Zubarik R, Fleischer DE, Mastropietro C, Lopez J, Carroll J, Benjamin S, et al. Prospective analysis of complications 30 days after outpatient colonoscopy. *Gastrointest Endosc*. 1999;50:322-8. [PMID: 10462650]
- 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;145:880-6. [PMID: 17179057]
- Gatto NM, Frucht H, Sundararajan V, Jacobson JS, Grann VR, Neugut AI. Risk of perforation after colonoscopy and sigmoidoscopy: a population-based study. *J Natl Cancer Inst*. 2003;95:230-6. [PMID: 12569145]
- Rathgeber SW, Wick TM. Colonoscopy completion and complication rates in a community gastroenterology practice. *Gastrointest Endosc*. 2006;64:556-62. [PMID: 16996349]
- Regula J, Rupinski M, Kraszewska E, Polkowski M, Pachlewski J, Orłowska J, et al. Colonoscopy in colorectal-cancer screening for detection of advanced neoplasia. *N Engl J Med*. 2006;355:1863-72. [PMID: 17079760]
- Ko CW, Riffle S, Shapiro JA, Saunders MD, Lee SD, Tung BY, et al. Incidence of minor complications and time lost from normal activities after screening or surveillance colonoscopy. *Gastrointest Endosc*. 2007;65:648-56. [PMID: 17173914]
- Lieberman DA, Weiss DG, Bond JH, Ahnen DJ, Garewal H, Chejfec G. Use of colonoscopy to screen asymptomatic adults for colorectal cancer. Veterans Affairs Cooperative Study Group 380. *N Engl J Med*. 2000;343:162-8. [PMID: 10900274]
- 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;135:1899-1906. [PMID: 18938166]
- 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;149:638-58. [PMID: 18838718]
27. **Warren JL, Klabunde CN, Schrag D, Bach PB, Riley GF.** Overview of the SEER-Medicare data: content, research applications, and generalizability to the United States elderly population. *Med Care.* 2002;40:IV-3-18. [PMID: 12187163]
28. **Centers for Medicare & Medicaid Services.** Healthcare Common Procedure Codes System (HCPCS). Accessed at www.cms.hhs.gov/MedHCPCSGenInfo/ on 16 April 2009.
29. **CPT 2005: Current Procedural Terminology.** Chicago: American Med Assoc; 2004.
30. **U.S. Public Health Service.** International Classification of Diseases, Ninth Revision. Washington, DC: U.S. Government Printing Office; 2003.
31. **Yabroff KR, Davis WW, Lamont EB, Fahey A, Topor M, Brown ML, et al.** Patient time costs associated with cancer care. *J Natl Cancer Inst.* 2007;99:14-23. [PMID: 17202109]
32. **Area Resource File (ARF).** Rockville, MD: U.S. Department of Health and Human Services; 2006.
33. **Charlson ME, Pompei P, Ales KL, MacKenzie CR.** A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;40:373-83. [PMID: 3558716]
34. **Romano PS, Roos LL, Jollis JG.** Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. *J Clin Epidemiol.* 1993;46:1075-9; discussion 1081-90. [PMID: 8410092]
35. **Graubard BI, Korn EL.** Predictive margins with survey data. *Biometrics.* 1999;55:652-9. [PMID: 11318229]
36. **Yield and Safety of Colonoscopy in Patients Older Than 80 Years** [clinical trial registration]. Accessed at www.clinicaltrials.gov/ct2/show/NCT00590434 on 5 May 2009.
37. **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;66:27-34. [PMID: 17591470]
38. **Karajeh MA, Sanders DS, Hurlstone DP.** Colonoscopy in elderly people is a safe procedure with a high diagnostic yield: a prospective comparative study of 2000 patients. *Endoscopy.* 2006;38:226-30. [PMID: 16528647]
39. **Stevens T, Burke CA.** Colonoscopy screening in the elderly: when to stop? *Am J Gastroenterol.* 2003;98:1881-5. [PMID: 12907348]
40. **Cooper GS.** Con: screening colonoscopy in the extreme elderly is not a wise choice. *Am J Gastroenterol.* 2006;101:1715-7; discussion 1717-8. [PMID: 16928249]
41. **American Society of Colon and Rectal Surgeons (ASCRS); American Society for Gastrointestinal Endoscopy (ASGE); Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), Wexner SD, Beck DE, Baron TH, Fanelli RD, Hyman N, Shen B, Wasco KE.** A consensus document on bowel preparation before colonoscopy: prepared by a task force from the American Society of Colon and Rectal Surgeons (ASCRS), the American Society for Gastrointestinal Endoscopy (ASGE), and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). *Surg Endosc.* 2006;20:1147-60. [PMID: 16763922]
42. **Beloosesky Y, Grinblat J, Weiss A, Grosman B, Gafter U, Chagnac A.** Electrolyte disorders following oral sodium phosphate administration for bowel cleansing in elderly patients. *Arch Intern Med.* 2003;163:803-8. [PMID: 12695271]
43. **Lichtenstein GR, Cohen LB, Uribarri J.** Review article: Bowel preparation for colonoscopy—the importance of adequate hydration. *Aliment Pharmacol Ther.* 2007;26:633-41. [PMID: 17697197]
44. **Gross CP, McAvay GJ, Krumholz HM, Paltiel AD, Bhasin D, Tinetti ME.** The effect of age and chronic illness on life expectancy after a diagnosis of colorectal cancer: implications for screening. *Ann Intern Med.* 2006;145:646-53. [PMID: 17088577]
45. **Fowles JB, Lawthers AG, Weiner JP, Garnick DW, Petrie DS, Palmer RH.** Agreement between physicians' office records and Medicare Part B claims data. *Health Care Financ Rev.* 1995;16:189-99. [PMID: 10151888]
46. **Javitt JC, McBean AM, Sastry SS, DiPaolo F.** Accuracy of coding in Medicare part B claims. Cataract as a case study. *Arch Ophthalmol.* 1993;111:605-7. [PMID: 8489437]
47. **Katz JN, Barrett J, Liang MH, Bacon AM, Kaplan H, Kieval RI, et al.** Sensitivity and positive predictive value of Medicare Part B physician claims for rheumatologic diagnoses and procedures. *Arthritis Rheum.* 1997;40:1594-600. [PMID: 9324013]
48. **Schenck AP, Klabunde CN, Warren JL, Peacock S, Davis WW, Hawley ST, et al.** Data sources for measuring colorectal endoscopy use among Medicare enrollees. *Cancer Epidemiol Biomarkers Prev.* 2007;16:2118-27. [PMID: 17932360]

PERSONAL ARCHIVES AND COLLECTIONS

Add favorite articles to your personal archives or retrieve collections for the following article types at www.annals.org:

- Randomized clinical trials
- Clinical Guidelines and Position Papers
- Editorials
- In the Clinic
- Medical Writings
- Book and software reviews
- On Being a Doctor and On Being a Patient
- Reviews
- Academia and Clinic

Current Author Addresses: Drs. Warren, Klabunde, and Brown: Applied Research Program, National Cancer Institute, Executive Plaza North Room 4005, 6130 Executive Boulevard, Bethesda, MD 20892-7344.

Dr. Mariotto: National Cancer Institute, Room 504, 6116 Executive Boulevard, Bethesda, MD 20892.

Ms. Meekins and Ms. Topor: Information Management Services, 12501 Prosperity Drive, Suite 200, Silver Spring, MD 20904.

Dr. Ransohoff: CB7080, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7080.

Author Contributions: Conception and design: J.L. Warren, C.N. Klabunde, A.B. Mariotto, M.L. Brown, D.F. Ransohoff.

Analysis and interpretation of the data: J.L. Warren, C.N. Klabunde, A.B. Mariotto, A. Meekins, M. Topor, M.L. Brown, D.F. Ransohoff.

Drafting of the article: C.N. Klabunde, M.L. Brown.

Critical revision of the article for important intellectual content: J.L. Warren, C.N. Klabunde, A.B. Mariotto, M.L. Brown, D.F. Ransohoff.

Final approval of the article: J.L. Warren, C.N. Klabunde, M.L. Brown, D.F. Ransohoff.

Statistical expertise: A.B. Mariotto.

Collection and assembly of data: C.N. Klabunde, A. Meekins, M. Topor.

Appendix Table. Identification Codes for All Diagnoses and Procedures

Characteristic	Code*
Medicare place of servicet	
Outpatient	22
ASC	24
Specialty	49
Preexisting condition	
Diverticulitis	562.01, 562.03, 562.11, 562.13
Inflammatory bowel disease (Crohn disease or ulcerative colitis)	555–556
Colon cancer	153–154.1, 159.0, 230.3, 230.4
Comorbid condition	
Stroke	431.x–438.x
COPD	496, 493.2, 491.x, 492.x
Atrial fibrillation or flutter	427.3x
Diabetes	250–250.9
CHF	428xx, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91
Type of colonoscopy‡	
Screening	G0105, G0121
Diagnostic	45378, 45.23
Polypectomy	45380, 45384, 45385, 45392, 45.42
HCPCS modifier code for incomplete procedure	53, 73, 74
Reason for colonoscopy	
Screening	V76.5x, V76.41, V76.49
Family or personal history of malignant gastrointestinal neoplasm	V10.05-06, V16.0, V12.72
Diverticulosis of colon	562.xx
Blood in stool or gastrointestinal bleeding	569.3, 578.1, 578.9, 792.1
Functional digestive disorders	
Diarrhea, NOS	787.91
Change in bowel habits	787.99
Functional digestive disorders, NEC	564.x
Hemorrhoids	455.xx
Benign neoplasm of colon and rectum or polyp	211.3, 211.4, 569.0
Anemia	280.xx, 285.xx
Other (diagnoses other than those above)	–

ASC = ambulatory surgical center; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; HCPCS = Healthcare Common Procedure Coding System; ICD-9-CM = International Classification of Disease, Ninth Edition, Clinical Modification; NEC = not elsewhere classified; NOS = not otherwise specified.

* Codes are ICD-9-CM diagnosis codes, except when specified otherwise.

† Medicare place of service codes.

‡ HCPCS and ICD-9-CM procedure codes.

Copyright of *Annals of Internal Medicine* is the property of American College of Physicians and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.