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ORIGINAL RESEARCH

The impact of anesthesia providers on major morbidity following screening colonoscopies

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Background and aims: Few studies evaluate the impact of anesthesia providers during procedures, such as colonoscopy, on low-risk patients. The objective of this study was to compare the effect of anesthesia providers on several outcome variables, including major morbidity, following screening colonoscopies.

Methods: A propensity-matched cohort study of 14,006 patients who enrolled with a national insurer offering health maintenance organization (HMO), preferred provider organization (PPO), and Medicare Advantage plans for a screening colonoscopy between July 1, 2005 and June 30, 2007 were studied. Records were evaluated for completion of the colonoscopy, new cancer diagnosis (colon, anal, rectal) within 6 months of the colonoscopy, new primary diagnosis of myocardial infarction (MI), new primary diagnosis of stroke, hospital admission within 7 days of the colonoscopy, and adherence to guidelines for use of anesthesia providers.

Results: The presence of an anesthesia provider did not affect major morbidity or the percent of completed exams. Overall morbidity within 7 days was very low. When an anesthesia provider was present, a nonsignificant trend toward greater cancer detection within 6 months of the procedure was observed. Adherence to national guidelines regarding the use of anesthesia providers for low-risk patients was poor.

Conclusion: A difference in outcome associated with the presence or absence of an anesthesia provider during screening colonoscopy in terms of MI, stroke, or hospital admission within 7 days of the procedure was not observed. Adherence to published guidelines for the use of anesthesia providers is low. The incidence of completed exams was unaffected by the presence of an anesthesia provider. However, a nonstatistically significant trend toward increased cancer detection requires further study.

Keywords: safety, complications, myocardial infarction, stroke, endoscopy, anesthesiology

Introduction

Colorectal cancer is the third leading cause of cancer death among men and women in the US. In 2009, an estimated 146,970 cases were diagnosed and an estimated 49,920 deaths occurred.[1] Current colon cancer prevention guidelines from the American Cancer Society are for average-risk men and women over 50 years of age to receive a flexible sigmoidoscopy every 5 years, a colonoscopy every 10 years, a double-contrast barium enema every 5 years, or a computed tomography colonography every 5 years to identify the presence of precancerous adenomatous polyps and detect colon cancer.[2] Despite these recommendations, screening colonoscopies remain uncommon. An estimate by the Behavioral Risk Factor Surveillance System in 2001 estimated that only 47.3% of adults above the age of 50 years had ever undergone a lower endoscopy.[3]

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Since screening colonoscopies are recommended for a large segment of the American population, the efficient use of resources is essential.[4,5] Colonoscopies are rarely performed without sedation.[6] Typically, sedative medications are administered to ensure patient comfort and to decrease awareness during the procedure. The overall cost of providing sedation for the colonoscopy increases if an anesthesia provider is present.

The value of having sedation for screening colonoscopies administered by anesthesia providers (anesthesiologists and/or certified registered nurse anesthetists [CRNAs]) has been debated. Much of the discussion centers around the use of propofol. Gastroenterologists frequently prefer propofol over other sedatives (such as opioids and benzodiazepines) due to propofol's quick onset and quick offset. The beneficial effect of propofol on throughput is an important consideration for gastroenterologists.[7,8] However, due to the US Food and Drug Administration's (FDA) restrictions for propofol use exclusively among providers who have been trained in the administration of general anesthesia and not involved in the conduct of the surgical/diagnostic procedure, many gastroenterologists will not use propofol without the presence of a licensed anesthesia provider.[9] Patients' satisfaction appears equivocal, when choosing between sedation with propofol versus sedation with an opioid and benzodiazepine combination.[10] However, researchers have stated that the presence of an anesthesia provider improves the quality of sedation and is cost-effective, allowing for a more complete and carefully conducted colonoscopy with improved health outcomes.[11] Recent studies have challenged these assertions. In a retrospective population-based study of 165,527 procedures in 100,359 Medicare beneficiaries, including 35,128 (21.2%) who received anesthesia services, Cooper et al demonstrated that anesthesia services were associated with an increased risk of aspiration (0.14%) compared to non-anesthesia services (0.10%) (P=0.02).[12] The increased risk of aspiration was the main factor accounting for the overall increase in complications (perforation and splenic injury) in patients undergoing colonoscopy with anesthesia services (0.22%) compared to without anesthesia services (0.16%) (P=0.0001).

Mortality following a screening colonoscopy is a rare event.[12] The overall 30-day mortality is 0.29% and was similar in the anesthesia (0.32%) and non-anesthesia (0.28%) groups (P=0.29). The overall 1-year mortality was 2.68% and was also similar in the anesthesia (2.82%) and non-anesthesia (2.64%) groups (P=0.06). Although the absolute risk of 30-day and 1-year mortality was low, the frequency of major cardiac or neurologic morbidity is unknown.

This study evaluates the impact of anesthesia services on major morbidity associated with myocardial infarction (MI) or stroke within 7 days following a screening colonoscopy. In addition, the efficacy, completion rate, incidence of a repeat colonoscopy within 6 months, and incidence of hospital admission within 7 days following a screening colonoscopy were also studied. We hypothesize that the presence of an anesthesia provider during colonoscopy would result in a more complete exam and an associated increased incidence of cancer detection. Additionally, we hypothesize that sedation administered by an anesthesia provider would be associated with fewer serious complications during and after a screening colonoscopy, due to better sedation management skills. Diagnostic outcomes and adverse events associated with the presence or absence of an anesthesia provider in a large population undergoing screening colonoscopies are evaluated. In addition, adherence to the 2004 joint national guidelines published by the American College of Gastroenterology (ACG), American Gastroenterological Association (AGA), and American Society of Gastrointestinal Endoscopy (ASGE) on the use of anesthesia providers during screening colonoscopies is studied.

Methods

After institutional review board approval, a cross-sectional and retrospective cohort analysis was conducted, using medical and pharmaceutical claims data for a representative population insured through commercial (HMO or PPO) or Medicare Advantage plans administered by Humana, Inc. Three electronic databases were merged. The member file database contained demographic information for each member per encounter (age, sex, type of insurance, and geographical region). The medical file database stored up to nine recorded International Classification of Diseases Ninth revision (ICD-9) codes per encounter, the primary code/reason for the encounter, the Current Procedural Terminology (CPT) codes, the CPT modifiers, and the G codes for procedures. The pharmacy file contained all Generic Product Identifier (GPI) numbers of pharmacy-dispensed medications per claim.

Study population

Between the identification period of July 1, 2005 and June 30, 2007, patients 50 years of age and older with at least one medical claim containing 45,355, 45,378, or 45,380 CPT

codes for colonoscopy and at least one G0121 or G0105 code were identified. To increase the likelihood of capturing only screening colonoscopies, patients with prior history (by ICD-9 code) of colorectal cancer, ulcerative colitis, or Crohn's disease involving the colon during the 12-month baseline period were excluded. The index date was defined as the date of the first medical claim for screening colonoscopy. Patients were eligible for the study if they had 18 months of continuous insurance enrollment, defined as at least 12 months of baseline coverage prior to the index date and at least 6 months of follow-up coverage. All codes used in the analysis are listed in Table S1.

Baseline characteristics

Baseline characteristics for all patients include the demographics (sex, age, race/ethnicity, and type of health insurance plan), the Deyo–Charlson Modified Comorbidity Index, and the Revised Cardiac Risk Index (RCRI). The American Society of Anesthesiologists' (ASA) Physical Status Classification was noted whenever it was coded. The Deyo–Charlson modified index is an extensively studied and validated comorbidity index, which has been adapted for use with ICD-9 databases and includes 17 diseases that have been selected and weighted on the basis of the strength of their association with mortality.[13]

Definition of average-risk and high-risk patients

All patients were defined as either average-risk or high-risk, based upon their baseline characteristics of the RCRI score calculated using baseline period claims data.[5] A subset of patients was also risk stratified by ASA status if the physical status CPT modifier was submitted either with the claim for screening colonoscopy or in the year prior to the index date. In the latter case, the most recent ASA status was used.

Average-risk patients were defined as those with an RCRI Class score of I or II, which means not having any risk factors or one risk factor of ischemic heart disease, history of congestive heart failure, history of cerebrovascular disease, insulin therapy for diabetes, or renal insufficiency. Patients with the risk factor of "insulin therapy for diabetes" must have had claims with an ICD-9 code for diabetes and a GPI code for insulin. High-risk patients were defined as those with an RCRI Class score of III or IV, which means two or more of the RCRI risk factors.

Presence or absence of anesthesia provider

The presence of an anesthesia provider was identified by the 00810 CPT code (anesthesia for lower intestinal endoscopic procedures, endoscope introduced distal to duodenum) submitted with the screening colonoscopy claim. If no claims for anesthesia services were associated with the submitted screening colonoscopy claim, then no anesthesia provider was presumed to be present.

Outcome and process measurements

Six months of follow-up claims were evaluated to identify whether the diagnosis of new colon cancer was made within 6 months of the colonoscopy; whether the colonoscopy was completed on the index date; whether repeating the colonoscopy was necessary; whether new primary ICD-9 diagnosis codes for MI and stroke were added within 7 days of the procedure; and whether hospital admission was required within 7 days. Each patient was followed for a 6-week period after the colonoscopy (latest follow-up was December 31, 2007). Adherence to ACG/AGA/ASGE guidelines, which support the administration of sedation by non-anesthesia providers to average-risk patients receiving a screening colonoscopy, was measured.[14]

Statistical analysis

Descriptive statistics were produced for each set of the study measures. Mean and reported standard deviation for continuous variables, and frequency counts and percentage for categorical variables, were reported. McNemar's test was used to determine the statistical significance of differences in categorical measures, including comparison of the ratings based on RCRI score and ASA status.

The study cohorts for evaluating the impact of an anesthesia provider were obtained by matching patients who had an anesthesia provider on the index date with those without an anesthesia provider, using the propensity score method on a 1:1 basis.[15] The Parsons algorithm selected matched pairs and the final cohorts, using the five digits match.[16]

Logistic regression using the generalized estimating equations (GEE) method was used to incorporate the matched pairs design and compare the effects of having an anesthesia provider present on the efficacy of colonoscopy in identifying colon cancer; the completion of the colonoscopy on the index date (as defined by coding that the examination was completed distal to the splenic flexure); the requirement for a repeat colonoscopy within 6 months; the development of an MI (a new primary ICD-9 code for the hospital encounter)

within 7 days of colonoscopy; the incidence of stroke (a new primary ICD-9 code for the hospital encounter) within 7 days of colonoscopy; and the incidence of a hospital admission within 7 days of the screening colonoscopy in both groups. SAS (v.9.1; SAS Institute Inc., Cary, NC, USA) was used for all statistical analyses.

Results

Baseline characteristics

Table 1 reports the demographics and the frequency of comorbid conditions among the patients who received screening colonoscopies. Inclusion criteria were met by 63,750 Humana members. Only 6.52% of subjects had an ASA score submitted, of which the most commonly reported score was a physician status 3.The majority of patients had 0 or 1 RCRI factors (73% and 19%, respectively). An anesthesia provider was present in 25.48% of screening colonoscopies.

Provider type, outcomes, and adverse events

High-risk patients were significantly more prevalent among the group having an anesthesia provider present during the colonoscopy (9.3% vs 7.5%, $P<0.0001$). Through propensity scoring using the Charlson comorbidity index and RCRI score, 14,006 colonoscopy patients were matched (7,003 patients in the group without an anesthesia provider and 7,003 with an anesthesia provider). The demographics of the two matched groups are shown in Table 2.

MIs (0.07%), strokes (0.06%), and hospital admissions (0.76%) within 7 days of the procedure were rare in both groups. A significant difference in the number of these events between the groups did not exist. The incidence of incomplete colonoscopies was not significantly different between those procedures performed with or without an anesthesia provider (1.39% and 1.14%, respectively). However, the incidence of repeat colonoscopies were significantly increased following a colonoscopy without an anesthesia provider as compared to with an anesthesia provider (2.40% vs 1.78%, $P<0.02$). A nonsignificant trend toward a greater likelihood of a cancer diagnosis was present if an anesthesia provider was involved (2.03% vs 1.7%, $P=0.13$) (Tables 3 and 4).

Adherence to guidelines

Nine point three one percent of the 16,243 patients who had an anesthesia provider qualified as high-risk by RCRI criteria. The remaining 90.69% of the patients were average-risk.

Table 1 Baseline demographic and clinical characteristics in whole population

Characteristics	Whole population N=63,750
Sex, N (%)	
Male	26,945 (42.27)
Female	36,805 (57.73)
Age group, N (%)	
50–<55	12,209 (19.15)
55–<60	10,283 (16.13)
60–<65	7,527 (11.81)
65–<70	9,851 (15.45)
70–<75	10,367 (16.26)
75–<80	7,895 (12.38)
80+	5,618 (8.81)
Age, mean (SD)	65.80 (10.11)
Type of insurance, N (%)	
Commercial	
HMO	12,084 (18.96)
PPO	16,954 (26.59)
Medicare ADV	
HMO	25,972 (40.74)
PFFS	8,061 (12.64)
PPO	679 (1.07)
Geographic region, N (%)	
West	3,669 (5.76)
South	42,183 (66.17)
Northeast	259 (0.41)
Midwest	17,639 (27.67)
Charlson comorbidity,[a] N (%)	
Myocardial infarction (score =1)	1,527 (2.40)
Congestive heart failure (score =1)	2,432 (3.81)
Peripheral vascular disease (score =1)	3,127 (4.91)
Cerebrovascular disease (score =1)	2,401 (3.77)
Dementia (score =1)	237 (0.37)
Chronic pulmonary disease (score =1)	6,057 (9.50)
Connective tissue disease–rheumatic disease (score =1)	1,330 (2.09)
Peptic ulcer disease (score =1)	558 (0.88)
Mild liver disease (score =1)	1,331 (2.09)
Diabetes without complications (score =1)	11,570 (18.15)
Diabetes with complications (score =2)	2,841 (4.46)
Paraplegia and hemiplegia (score =2)	160 (0.25)
Renal disease (score =2)	1,833 (2.88)
Cancer (score =2)	4,361 (6.84)
Moderate or severe liver disease (score =3)	87 (0.14)
Metastatic carcinoma (score =6)	293 (0.46)
AIDS/HIV (score =6)	68 (0.11)
Charlson comorbidity score,[a] mean (SD)	0.81 (1.43)
Incomplete colonoscopy procedure,[b] N (%)	810 (1.27)
Service site,[b] N (%)	
Ambulatory surgical center	31,396 (49.25)
Hospital outpatient	27,229 (42.71)
Physician office	4,524 (7.10)
Hospital inpatient	576 (0.90)
Other provider	25 (0.04)
Presence of anesthesia provider,[c] N (%)	16,243 (25.48)

(*Continued*)

Table 1 (*Continued*)

Characteristics	Whole population N=63,750
Personal history of colonic polyps,[d] N (%)	3,693 (5.79)
ASA status,[e] N (%)	
P1	344 (0.54)
P2	1,587 (2.49)
P3	2,085 (3.27)
P4	136 (0.21)
P5	4 (0.01)
RCRI factors,[f] N (%)	
0	46,825 (73.45)
1	11,844 (18.58)
2	3,709 (5.82)
3	1,079 (1.69)
4	257 (0.40)
5	36 (0.06)

Notes: [a]Charlson comorbidity was calculated using medical claims 365 days prior to index date; [b]incomplete procedure (CPT modifiers 52, 53, and 74), provider specialty, service site were defined by using medical claims containing the indexed colonoscopy procedure; [c]presence of anesthesia provider was defined by the presence of CPT codes 00810 within any medical claim on index date. [d]Personal history of colonic polyps was defined as follows: ICD-9 codes 211.3, 211.4, and V12.72 within 365 days prior to index date, or V12.72 on index date; [e]CPT modifiers from medical claims within 1 year prior to index date (including) were used to defined patients' ASA status. If a patient had different ASA statuses within this period, the latest one was used; [f]RCRI factors were defined using medical claims within 365 days prior to index date:
1) history of ischemic heart disease: 410.xx, 411.xx, 412.xx, 413.xx, 414.xx
2) history of congestive heart failure: 428.xx
3) history of cerebrovascular disease: 43.
Abbreviations: ADV, Advantage; ASA, American Society of Anesthesiologists; CPT, Current Procedural Terminology; HMO, health maintenance organization; ICD-9, International Classification of Diseases Ninth revision; PPO, preferred provider organization; RCRI, Revised Cardiac Risk Index; SD, standard deviation; PFFS, private fee-for-service.

The demographics of those with an anesthesia provider versus those without an anesthesia provider are shown on Table 5.

Discussion

This retrospective observational study of a large health benefits claims database evaluated the impact of the presence or absence of an anesthesia provider on major morbidity for a large population of average- and high-risk patients undergoing screening colonoscopies. Anesthesia providers were present 25.48% of the time, which is consistent with previously published US and Canadian rates of 27.8% and 19.1%, respectively.[6,17]

Our study demonstrates that, in a population of predominantly average-risk patients, the presence of an anesthesia provider during a colonoscopy has no impact on the incidence of MI or stroke. However, a statistically significant decrease in the rate of repeated colonoscopies (0.7%) was associated with the presence of an anesthesia provider. Although further study with sufficient power is needed to confirm the finding of a nonsignificant trend toward increased cancer detection, the decrease in repeat colonoscopies may be consistent with the nonsignificant trend toward greater cancer detection when an anesthesia provider is present. If a gastroenterologist were more inclined to avoid repeating a colonoscopy or aborting a procedure when an anesthesia provider manages the commonly occurring complications of hypoxemia (55.6%), bradycardia (5.6%), and hypotension (8.9%), they may identify more lesions and be more confident that a sufficiently thorough exam was performed.[18]

Guidelines prepared jointly by the ACG, AGA, and ASGE, addressing the issue of sedation during routine lower endoscopic procedures, do not support the administration of moderate sedation by specially trained anesthesia providers to average-risk patients. However, for high-risk patients, the guidelines suggest that the administration of sedation by an anesthesiologist or other anesthesia provider might be considered.[17] Conflicting results regarding outcomes and adverse events exist.[19] The ASA has equivocated on whether the immediate availability of a provider with postgraduate training in anesthesiology increases the likelihood of a satisfactory outcome or decreases the associated risks associated with moderate sedation (more commonly performed on average-risk patients). For deep sedation or when procedures are performed on high-risk patients, the ASA agrees that the immediate availability of an anesthesiologist increases the likelihood of satisfactory sedation and decreases the likelihood of adverse outcomes.[20] However, recent data suggests that the use of propofol by anesthesiologists has been associated with an increased risk of aspiration pneumonia among Medicare patients undergoing outpatient colonoscopy.[12] Agostoni et al found that pulmonary aspiration is the most common significant complication of a colonoscopy.[21] Additional evidence attributes the risk of respiratory complications and infections following endoscopies and colonoscopies to the depth of sedation achieved during the procedure.[22]

National guidelines regarding the use of anesthesia providers are not commonly followed in clinical practice. Currently, an endoscopist's decision to include an anesthesia provider has largely been dependent upon their level of comfort managing the administration of sedation and their desire to best meet the needs of their patients. The implementation of any guideline requires an understanding of existing trends in clinical practice and a commitment at the national, regional, and local levels to adapt evidence-based recommendations to available resources. In the absence of any outcome study, individual physicians may rationalize more care than less.

Table 2 Baseline demographic and clinical characteristics after propensity score matching (N=14,006)

Characteristics	Colonoscopy without anesthesia provider N=7,003	Colonoscopy with anesthesia provider N=7,003	*P*-value
Sex, N (%)			
Male	2,755 (39.34)	2,732 (40.01)	
Female	4,248 (60.66)	4,271 (60.99)	0.6905[a]
Age, mean (SD)	65.57 (9.96)	65.39 (10.05)	0.2925[b]
Type of insurance, N (%)			
Commercial			
HMO	1,172 (16.74)	1,254 (17.91)	0.1190[a]
PPO	1,952 (27.87)	1,982 (28.30)	
Medicare ADV			
HMO	3,149 (44.97)	3,112 (44.44)	
PFFS	674 (9.62)	607 (8.67)	
PPO	56 (0.80)	48 (0.69)	
Geographic region, N (%)			
West	237 (3.38)	208 (2.97)	0.1415[a]
South	5,936 (84.76)	6,030 (86.11)	
Northeast	19 (0.27)	20 (0.29)	
Midwest	811 (11.58)	745 (10.64)	
Charlson comorbidity score, mean (SD)	0.68 (1.32)	0.67 (1.32)	0.5103[b]
Service site, N (%)			
Ambulatory surgical center	4,390 (62.69)	4,298 (61.37)	0.2178[a]
Hospital outpatient	2,166 (30.93)	2,206 (31.50)	
Physician office	407 (5.81)	465 (6.64)	
Hospital inpatient	37 (0.53)	32 (0.46)	
Other provider	3 (0.04)	2 (0.03)	
Personal history of colonic polyps, N (%)			
Yes	260 (3.71)	234 (3.34)	0.2337[a]
RCRI risk group, N (%)			
High	430 (6.14)	444 (6.34)	0.6248[a]
RCRI factors, N (%)			
Ischemic heart disease (yes)	1,049 (14.98)	1,070 (15.28)	0.6205[a]
Congestive heart failure (yes)	239 (3.41)	257 (3.67)	0.4105[a]
Cerebrovascular disease (yes)	437 (6.24)	484 (6.91)	0.1091[a]
Renal insufficiency (yes)	257 (3.67)	205 (2.93)	0.0139[a]
Diabetes with insulin therapy (yes)	176 (2.51)	147 (2.10)	0.1026[a]
Hyperlipidemia, N (%)			
Yes	4,686 (66.91)	4,648 (66.37)	0.4959[a]
Hypertension, N (%)			
Yes	4,156 (59.35)	4,204 (60.03)	0.4083[a]
Obesity, N (%)			
Yes	404 (5.77)	443 (6.33)	0.1668[a]

Notes: [a]*P*-value for comparison between anesthesia without provider and with provider, calculated by chi-square test; [b]*P*-value for comparison between anesthesia without provider and with provider, calculated by *t*-test with equal variance.

Abbreviations: ADV, Advantage; HMO, health maintenance organization; PFFS, private fee-for-service; PPO, preferred provider organization; RCRI, Revised Cardiac Risk Index; SD, standard deviation.

Our study contains a number of limitations related to its retrospective nature and use of insurance claims data. The "presence of anesthesia provider" does not differentiate between the presence of an anesthesiologist (or the subset of board-certified anesthesiologists) or a CRNA. Perhaps measuring outcomes separately would reveal different outcomes between the two provider groups. Similarly, in the "absence of anesthesia provider" group, almost all patients still received some degree of sedation. However, no method existed to determine if the sedation was administered by another physician or registered nurse. Furthermore, the medications used to provide sedation could not be identified. Medications represent a potential confounding variable, as they differ in their safety and pharmacologic profiles. As an example, anesthesia providers are more likely to utilize medications such as propofol, which has more profound pharmacodynamic effects than other sedatives. Data on the type of anesthesia administered (general anesthesia, deep

Table 3 Comparison of colonoscopy outcomes

Outcomes	Colonoscopy without anesthesia provider	Colonoscopy with anesthesia provider	Unadjusted			Adjusted*		
	N=7,003	N=7,003	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Completed colonoscopy on index day, N (%)	6,906 (98.61)	6,923 (98.86)	1.22	0.90–1.64	0.2020	1.23	0.91–1.66	0.1797
Repeated colonoscopy within 180 days post-index day, N (%)**	168 (2.40)	125 (1.78)	0.74	0.59–0.93	0.0114	0.75	0.59–0.96	0.0195
Colorectal cancer identified on index day and within 180 days post-index day, N (%)	119 (1.7)	142 (2.03)	1.20	0.94–1.53	0.1487	1.21	0.95–1.55	0.1266
Colon	104 (1.49)	128 (1.83)	1.24	0.95–1.60	0.1110	1.25	0.96–1.63	0.0942
Rectum and anus	72 (1.03)	94 (1.34)	1.31	0.96–1.78	0.0867	1.33	0.97–1.81	0.0761
Hospital admission on index day and within 7 days post-index day, N (%)	58 (0.83)	49 (0.70)	0.97	0.86–1.09	0.6205	0.97	0.86–1.09	0.5848

Notes: *For MI, adjusting for age, sex, and previous history of MI. For stroke, adjusting for age, sex, and previous history of cerebrovascular disease. For other outcomes, adjusting for variables used for propensity score matching (age, sex, geographic region, RCRI group, etc) and status of colonoscopy procedure (not used for completed colonoscopy outcome). GEE analysis was performed to adjust for correlation within matched pairs; **all types of colonoscopy procedures defined in Table 4.
Abbreviations: CI, confidence interval; GEE, generalized estimating equations; MI, myocardial infarction; OR, odds ratio; RCRI, Revised Cardiac Risk Index.

sedation, or moderate sedation) was not available. However, given the extremely low incidence of complications, the likely that further stratification of providers, depth of anesthesia, or type of sedative medications administered would change our conclusions is low. Finally, polyp yield from the colonoscopy procedure and histology and staging for cases of colon cancer identified were not available in the dataset, which might have caused a missed benefit of having an anesthesia provider present, if effectiveness of the screening examination was considered using that data. There were a very small number of cardiovascular events from which to draw conclusions about the choice of professionals providing sedation.

Evaluating the effectiveness of the therapies and the usefulness of anesthesia providers for routine screenings, treatments, or symptom management is a national imperative of medical research. This study helps formulate updated policies related to endoscopic sedation and advances the understanding of health care expenditures about the outcomes related to sedation during colonoscopy. Through additional carefully conducted research and thoughtful analysis, physicians and guideline-setting organizations will be able to make recommendations on the optimal use of health resources, for the benefit of individual patients and the health of our society.

Table 4 Comparison of cardiovascular outcomes

Outcomes	Colonoscopy without anesthesia provider	Colonoscopy with anesthesia provider	Unadjusted			Adjusted*		
	N=7,003	N=7,003	OR	95% CI	*P*-value	OR	95% CI	*P*-value
MI on index day and within 7 days post-index day, N (%)	4 (0.06)	13 (0.19)	3.25	1.06–9.99	0.0392	3.20	1.03–9.90	0.0442
MI (primary diagnosis) on index day and within 7 days post-index day, N (%)	3 (0.04)	7 (0.10)	2.33	0.60–9.04	0.2195	2.25	0.58–8.77	0.2422
Stroke on index day and within 7 days post-index day, N (%)	10 (0.14)	10 (0.14)	1.00	0.42–2.41	1.0000	0.90	0.38–2.18	0.8234
Stroke (primary diagnosis) on index day and within 7 days post-index day, N (%)	5 (0.07)	4 (0.06)	0.80	0.21–2.98	0.7394	0.76	0.20–2.81	0.6765

Notes: *For MI, adjusting for age, sex, and previous history of MI. For stroke, adjusting for age, sex, and previous history of cerebrovascular disease. GEE analysis was performed to adjust for correlation within matched pairs.
Abbreviations: CI, confidence interval; GEE, generalized estimating equations; MI, myocardial infarction; OR, odds ratio.

Table 5 Baseline demographic and clinical characteristics (N=63,750)

Characteristics	Colonoscopy without anesthesia provider N=47,507	Colonoscopy with anesthesia provider N=16,243	*P*-value
Sex, N (%)			
Male	20,425 (42.99)	6,520 (40.14)	
Female	27,082 (57.01)	9,723 (59.86)	<0.0001[a]
Age, mean (SD)	65.28 (10.10)	67.31 (9.99)	<0.0001[b]
Type of insurance, N (%)			
Commercial			
HMO	9,278 (19.53)	2,806 (17.28)	<0.0001[a]
PPO	14,019 (29.51)	2,935 (18.07)	
Medicare ADV			
HMO	16,885 (35.54)	9,087 (55.94)	
PFFS	6,803 (14.32)	1,258 (7.74)	
PPO	522 (1.10)	157 (0.97)	
Geographic region, N (%)			
West	3,339 (7.03)	330 (2.03)	<0.0001[a]
South	27,454 (57.79)	14,729 (90.68)	
Northeast	115 (0.24)	144 (0.89)	
Midwest	16,599 (34.94)	1,040 (6.40)	
Charlson comorbidity score, mean (SD)	0.76 (1.40)	0.93 (1.52)	<0.0001[c]
Service site, N (%)			
Ambulatory surgical center	19,717 (41.50)	11,679 (71.90)	<0.0001[a]
Hospital outpatient	23,568 (49.61)	3,661 (22.54)	
Physician office	3,693 (7.77)	831 (5.12)	
Hospital inpatient	507 (1.07)	69 (0.42)	
Other provider	22 (0.05)	3 (0.02)	
Personal history of colonic polyps, N (%)			
Yes	1,990 (4.19)	1,703 (10.48)	<0.0001[a]
RCRI risk group, N (%)			
High	3,568 (7.51)	1,513 (9.31)	<0.0001[a]
RCRI factors, N (%)			
Ischemic heart disease (yes)	7,666 (16.14)	3,449 (21.23)	<0.0001[a]
Congestive heart failure (yes)	2,161 (4.55)	791 (4.87)	0.0929[a]
Cerebrovascular disease (yes)	3,551 (7.47)	1,544 (9.51)	<0.0001[a]
Renal insufficiency (yes)	1,835 (3.86)	788 (4.85)	<0.0001[a]
Diabetes with insulin therapy (yes)	1,422 (2.99)	500 (3.08)	0.5844[a]
Hyperlipidemia, N (%)			
Yes	28,902 (60.84)	11,353 (69.89)	<0.0001[a]
Hypertension, N (%)			
Yes	27,665 (58.23)	10,514 (64.73)	<0.0001[a]
Obesity, N (%)			
Yes	2,971 (6.25)	1,295 (7.97)	<0.0001[a]

Notes: [a]*P*-value for comparison between colonoscopy without anesthesia provider and with anesthesia provider, calculated by chi-square test; [b]*P*-value for comparison between colonoscopy without anesthesia provider and with anesthesia provider, calculated by *t*-test with equal variance; [c]*P*-value for comparison between colonoscopy without anesthesia provider and with anesthesia provider, calculated by *t*-test with unequal variance.

Abbreviations: ADV, Advantage; HMO, health maintenance organization; PFFS, private fee-for-service; PPO, preferred provider organization; RCRI, Revised Cardiac Risk Index; SD, standard deviation.

Conclusion

The presence of an anesthesia provider during a screening colonoscopy did not affect the incidence of completed colonoscopies or the incidence of significant morbidity. MI and stroke following screening colonoscopies are very rare. A nonstatistically significant trend toward increased cancer detection was found, when an anesthesia provider was present. Furthermore, repeat colonoscopies were significantly increased following a colonoscopy without an anesthesia provider. Adherence to 2004 published guidelines by several societies representing gastroenterologists regarding the use of anesthesia providers was poor.

Author contributions

All authors contributed toward data analysis, drafting and revising the paper and agree to be accountable for all aspects of the work.

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Disclosure

Qianli Ma and Claudia Uribe are employed by Humana. John Hanna was employed by Humana at the time the project was conducted. The other authors report no conflicts of interest in this work.

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Supplementary table

Table S1

CPT code	Description
00810	Presence of anesthesia provider
45355	Colonoscopy, rigid or flexible, transabdominal via colostomy, single or multiple
45378	Colonoscopy, flexible, proximal to splenic flexure; diagnostic, with or without collection of specimen(s) by brushing or washing, with or without colon decompression
45380	Colonoscopy, flexible, proximal to splenic flexure; with biopsy, single or multiple
Modifier 52	Incomplete procedure
Modifier 53	Incomplete procedure
Modifier 74	Incomplete procedure
Modifier P1	Normal healthy patient
Modifier P2	Patient with mild systemic disease
Modifier P3	Patient with severe systemic disease
Modifier P4	Patient with severe systemic disease that is a constant threat to life
Modifier P5	Moribund patient who is not expected to survive without the operation
G code	
G0121	Colorectal screening; colonoscopy on individual not meeting criteria for high risk
G0105	Colorectal screening; colonoscopy on individual meeting criteria for high risk
V code	
V10.05	Personal history of malignant neoplasm of large intestine
V10.06	Personal history of malignant neoplasm of rectum, rectosigmoid junction, and anus
ICD-9 code	
153	Malignant neoplasm of colon
153.0	Malignant neoplasm of hepatic flexure
153.1	Malignant neoplasm of transverse colon
153.2	Malignant neoplasm of descending colon
153.3	Malignant neoplasm of sigmoid colon
153.4	Malignant neoplasm of cecum
153.5	Malignant neoplasm of appendix
153.6	Malignant neoplasm of ascending colon
153.7	Malignant neoplasm of splenic flexure
153.8	Malignant neoplasm of other specified sites of large intestine
153.9	Malignant neoplasm of colon, unspecified site
154	Malignant neoplasm of rectum, rectosigmoid junction, and anus
154.0	Malignant neoplasm of rectosigmoid junction
154.1	Malignant neoplasm of rectum
154.2	Malignant neoplasm of anal canal
154.3	Malignant neoplasm of anus, unspecified site
154.8	Malignant neoplasm of other sites of rectum, rectosigmoid junction, and anus
ICD-9 code	
230.3	Carcinoma in situ of colon
230.6	Carcinoma in situ of rectum
230.7	Carcinoma in situ of anal canal
230.8	Carcinoma in situ of anus, unspecified
235.2	Neo uncertain behavior
239.0	Neo unspecified
555	Regional enteritis
555.1	Regional enteritis, large intestine
555.2	Regional enteritis, small intestine with large intestine
555.9	Regional enteritis, unspecified site
556	Ulcerative colitis
556.0	Ulcerative (chronic) enterocolitis
556.1	Ulcerative (chronic) ileocolitis
556.2	Ulcerative (chronic) proctitis
556.3	Ulcerative (chronic) proctosigmoiditis
556.4	Pseudopolyposis of colon
556.5	Left-sided ulcerative (chronic) colitis
556.6	Universal ulcerative (chronic) colitis
556.8	Other ulcerative colitis
556.9	Ulcerative colitis, unspecified

(*Continued*)

Table S1 (*Continued*)

CPT code	Description
410	Acute myocardial infarction
410.0	Acute myocardial infarction of anterolateral wall
410.00	Acute myocardial infarction of anterolateral wall, episode of care unspecified
410.01	Acute myocardial infarction of anterolateral wall, initial episode of care
410.02	Acute myocardial infarction of anterolateral wall, subsequent episode of care
410.1	Acute myocardial infarction of other anterior wall
410.0	Acute myocardial infarction of other anterior wall, episode of care unspecified
410.11	Acute myocardial infarction of other anterior wall, initial episode of care
410.12	Acute myocardial infarction of other anterior wall, subsequent episode of care
410.2	Acute myocardial infarction of inferolateral wall
410.20	Acute myocardial infarction of inferolateral wall, episode of care unspecified
410.21	Acute myocardial infarction of inferolateral wall, initial episode of care
410.22	Acute myocardial infarction of inferolateral wall, subsequent episode of care
410.3	Acute myocardial infarction of inferoposterior wall
410.30	Acute myocardial infarction of inferoposterior wall, episode of care unspecified
410.31	Acute myocardial infarction of inferoposterior wall, initial episode of care
410.32	Acute myocardial infarction of inferoposterior wall, subsequent episode of care
410.4	Acute myocardial infarction of other inferior wall
410.40	Acute myocardial infarction of other inferior wall, episode of care unspecified
410.41	Acute myocardial infarction of other inferior wall, initial episode of care
ICD-9 code	
410.42	Acute myocardial infarction of other inferior wall, subsequent episode of care
410.5	Acute myocardial infarction of other lateral wall
410.50	Acute myocardial infarction of other lateral wall, episode of care unspecified
410.51	Acute myocardial infarction of other lateral wall, initial episode of care
410.52	Acute myocardial infarction of other lateral wall, subsequent episode of care
410.6	Acute myocardial infarction, true posterior wall infarction
410.60	Acute myocardial infarction, true posterior wall infarction, episode of care unspecified
410.61	Acute myocardial infarction, true posterior wall infarction, initial episode of care
410.62	Acute myocardial infarction, true posterior wall infarction, subsequent episode of care
410.7	Acute myocardial infarction, subendocardial infarction
410.70	Acute myocardial infarction, subendocardial infarction, episode of care unspecified
410.71	Acute myocardial infarction, subendocardial infarction, initial episode of care
410.72	Acute myocardial infarction, subendocardial infarction, subsequent episode of care
410.8	Acute myocardial infarction of other specified sites
410.80	Acute myocardial infarction of other specified sites, episode of care unspecified
410.81	Acute myocardial infarction of other specified sites, initial episode of care
410.82	Acute myocardial infarction of other specified sites, subsequent episode of care
410.9	Acute myocardial infarction, unspecified site
410.90	Acute myocardial infarction, unspecified site, episode of care unspecified
410.91	Acute myocardial infarction, unspecified site, initial episode of care
410.92	Acute myocardial infarction, unspecified site, subsequent episode of care
411	Other acute and subacute forms of ischemic heart disease
411.0	Postmyocardial infarction syndrome
411.1	Intermediate coronary syndrome
411.8	Other acute and subacute forms of ischemic heart disease
411.81	Acute coronary occlusion without myocardial infarction
411.89	Other acute and subacute form of ischemic heart disease
412	Old myocardial infarction
413	Angina pectoris
413.0	Angina decubitus
413.1	Prinzmetal angina
413.9	Other and unspecified angina pectoris
414	Other forms of chronic ischemic heart disease
414.0	Coronary atherosclerosis
414.00	Coronary atherosclerosis of unspecified type of vessel, native, or graft
414.01	Coronary atherosclerosis of native coronary artery
414.02	Coronary atherosclerosis of autologous vein bypass graft
414.03	Coronary atherosclerosis of nonautologous biological bypass graft

(*Continued*)

Table S1 (*Continued*)

CPT code	Description
414.04	Coronary atherosclerosis of artery bypass graft
414.05	Coronary atherosclerosis of unspecified type of bypass graft
ICD-9 code	
414.06	Coronary atherosclerosis, of native coronary artery of transplanted heart
414.07	Coronary atherosclerosis, of bypass graft (artery) (vein) of transplanted heart
414.1	Aneurysm and dissection of heart
414.10	Aneurysm of heart
414.11	Aneurysm of coronary vessels
414.12	Dissection of coronary artery
414.19	Other aneurysm of heart
414.2	Chronic total occlusion of coronary artery
414.8	Other specified forms of chronic ischemic heart disease
414.9	Unspecified chronic ischemic heart disease
430	Subarachnoid hemorrhage
431	Intracerebral hemorrhage
432	Other and unspecified intracranial hemorrhage
432.0	Nontraumatic extradural hemorrhage
432.1	Subdural hemorrhage
432.9	Unspecified intracranial hemorrhage
433	Occlusion and stenosis of precerebral arteries
433.0	Occlusion and stenosis of basilar artery
433.00	Occlusion and stenosis of basilar artery without mention of cerebral infarction
433.01	Occlusion and stenosis of basilar artery with cerebral infarction
433.1	Occlusion and stenosis of carotid artery
433.10	Occlusion and stenosis of carotid artery without mention of cerebral infarction
433.11	Occlusion and stenosis of carotid artery with cerebral infarction
433.2	Occlusion and stenosis of vertebral artery
433.20	Occlusion and stenosis of vertebral artery without mention of cerebral infarction
433.21	Occlusion and stenosis of vertebral artery with cerebral infarction
433.3	Occlusion and stenosis of multiple and bilateral precerebral arteries
433.30	Occlusion and stenosis of multiple and bilateral precerebral arteries without mention of cerebral infarction
433.31	Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction
433.8	Occlusion and stenosis of other specified precerebral artery
433.80	Occlusion and stenosis of other specified precerebral artery without mention of cerebral infarction
433.81	Occlusion and stenosis of other specified precerebral artery with cerebral infarction
433.9	Occlusion and stenosis of unspecified precerebral artery
433.90	Occlusion and stenosis of unspecified precerebral artery without mention of cerebral infarction
433.91	Occlusion and stenosis of unspecified precerebral artery with cerebral infarction
434	Occlusion of cerebral arteries
434.0	Cerebral thrombosis
434.00	Cerebral thrombosis without mention of cerebral infarction
434.01	Cerebral thrombosis with cerebral infarction
ICD-9 code	
434.1	Cerebral embolism
434.10	Cerebral embolism without mention of cerebral infarction
434.11	Cerebral embolism with cerebral infarction
434.9	Unspecified cerebral artery occlusion
434.90	Unspecified cerebral artery occlusion without mention of cerebral infarction
434.91	Unspecified cerebral artery occlusion with cerebral infarction
435	Transient cerebral ischemia
435.0	Basilar artery syndrome
435.1	Vertebral artery syndrome
435.2	Subclavian steal syndrome
435.3	Vertebrobasilar artery syndrome
435.8	Other specified transient cerebral ischemias
435.9	Unspecified transient cerebral ischemia
436	Acute, but ill-defined, cerebrovascular disease
437	Other and ill-defined cerebrovascular disease
437.0	Cerebral atherosclerosis
437.1	Other generalized ischemic cerebrovascular disease
437.2	Hypertensive encephalopathy
437.3	Cerebral aneurysm, nonruptured
437.4	Cerebral arteritis

(*Continued*)

Table S1 (*Continued*)

CPT code	Description
437.5	Moyamoya disease
437.6	Nonpyogenic thrombosis of intracranial venous sinus
437.7	Transient global amnesia
437.8	Other ill-defined cerebrovascular disease
437.9	Unspecified cerebrovascular disease
438	Late effects of cerebrovascular disease
438.0	Cognitive deficits due to cerebrovascular disease
438.1	Speech and language deficits due to cerebrovascular disease
439.10	Unspecified speech and language deficit due to cerebrovascular disease
438.11	Aphasia due to cerebrovascular disease
438.12	Dysphasia due to cerebrovascular disease
438.19	Other speech and language deficits due to cerebrovascular disease
438.2	Hemiplegia/hemiparesis due to cerebrovascular disease
438.20	Hemiplegia affecting unspecified side due to cerebrovascular disease
438.21	Hemiplegia affecting dominant side due to cerebrovascular disease
438.22	Hemiplegia affecting nondominant side due to cerebrovascular disease
438.3	Monoplegia of upper limb due to cerebrovascular disease
438.30	Monoplegia of upper limb affecting unspecified side due to cerebrovascular disease
438.31	Monoplegia of upper limb affecting dominant side due to cerebrovascular disease
438.32	Monoplegia of upper limb affecting nondominant side due to cerebrovascular disease
ICD-9 code	
438.4	Monoplegia of lower limb due to cerebrovascular disease
438.40	Monoplegia of lower limb affecting unspecified side due to cerebrovascular disease
438.41	Monoplegia of lower limb affecting dominant side due to cerebrovascular disease
438.42	Monoplegia of lower limb affecting nondominant side due to cerebrovascular disease
438.5	Other paralytic syndrome due to cerebrovascular disease
438.50	Other paralytic syndrome affecting unspecified side due to cerebrovascular disease
438.51	Other paralytic syndrome affecting dominant side due to cerebrovascular disease
438.52	Other paralytic syndrome affecting nondominant side due to cerebrovascular disease
438.6	Alteration of sensations as late effect of cerebrovascular disease
438.7	Disturbance of vision as late effect of cerebrovascular disease
438.8	Other late effects of cerebrovascular disease due to cerebrovascular disease
438.81	Apraxia due to cerebrovascular disease
438.82	Dysphagia due to cerebrovascular disease
438.83	Facial weakness as late effect of cerebrovascular disease
438.84	Ataxia as late effect of cerebrovascular disease
438.85	Vertigo as late effect of cerebrovascular disease
438.89	Other late effects of cerebrovascular disease
438.9	Unspecified late effects of cerebrovascular disease due to cerebrovascular disease
428	Heart failure
428.0	Congestive heart failure, unspecified
428.1	Left heart failure
428.2	Systolic heart failure
428.20	Unspecified systolic heart failure
428.21	Acute systolic heart failure
428.22	Chronic systolic heart failure
428.23	Acute on chronic systolic heart failure
428.3	Diastolic heart failure
428.30	Unspecified diastolic heart failure
428.31	Acute diastolic heart failure
428.32	Chronic diastolic heart failure
428.33	Acute on chronic diastolic heart failure
428.4	Combined systolic and diastolic heart failure
428.40	Unspecified combined systolic and diastolic heart failure
428.41	Acute combined systolic and diastolic heart failure
428.42	Chronic combined systolic and diastolic heart failure
428.43	Acute on chronic combined systolic and diastolic heart failure
428.9	Unspecified heart failure
250	Diabetes mellitus
250.0	Diabetes mellitus without mention of complication

(*Continued*)

Table S1 (*Continued*)

CPT code	Description
ICD-9 code	
250.00	Diabetes mellitus without mention of complication, type II or unspecified type, not stated as uncontrolled
250.01	Diabetes mellitus without mention of complication, type I (juvenile type), not stated as uncontrolled
250.02	Diabetes mellitus without mention of complication, type II or unspecified type, uncontrolled
250.03	Diabetes mellitus without mention of complication, type I (juvenile type), uncontrolled
250.1	Diabetes with ketoacidosis
250.10	Diabetes with ketoacidosis, type II or unspecified type, not stated as uncontrolled
250.11	Diabetes with ketoacidosis, type I (juvenile type), not stated as uncontrolled
250.12	Diabetes with ketoacidosis, type II or unspecified type, uncontrolled
250.13	Diabetes with ketoacidosis, type I (juvenile type), uncontrolled
250.2	Diabetes with hyperosmolarity
250.20	Diabetes with hyperosmolarity, type II or unspecified type, not stated as uncontrolled
250.21	Diabetes with hyperosmolarity, type I (juvenile type), not stated as uncontrolled
250.22	Diabetes with hyperosmolarity, type II or unspecified type, uncontrolled
250.23	Diabetes with hyperosmolarity, type I (juvenile type), uncontrolled
250.3	Diabetes with other coma
250.30	Diabetes with other coma, type II or unspecified type, not stated as uncontrolled
250.31	Diabetes with other coma, type I (juvenile type), not stated as uncontrolled
250.32	Diabetes with other coma, type II or unspecified type, uncontrolled
250.33	Diabetes with other coma, type I (juvenile type), uncontrolled
250.4	Diabetes with renal manifestations
250.40	Diabetes with renal manifestations, type II or unspecified type, not stated as uncontrolled
250.41	Diabetes with renal manifestations, type I (juvenile type), not stated as uncontrolled
250.42	Diabetes with renal manifestations, type II or unspecified type, uncontrolled
250.43	Diabetes with renal manifestations, type I (juvenile type), uncontrolled
250.5	Diabetes with ophthalmic manifestations
250.50	Diabetes with ophthalmic manifestations, type II or unspecified type, not stated as uncontrolled
250.51	Diabetes with ophthalmic manifestations, type I (juvenile type), not stated as uncontrolled
250.52	Diabetes with ophthalmic manifestations, type II or unspecified type, uncontrolled
250.53	Diabetes with ophthalmic manifestations, type I (juvenile type), uncontrolled
250.6	Diabetes with neurological manifestations
250.60	Diabetes with neurological manifestations, type II or unspecified type, not stated as uncontrolled
250.61	Diabetes with neurological manifestations, type I (juvenile type), not stated as uncontrolled
250.62	Diabetes with neurological manifestations, type II or unspecified type, uncontrolled
250.63	Diabetes with neurological manifestations, type I (juvenile type), uncontrolled
250.7	Diabetes with peripheral circulatory disorders
250.70	Diabetes with peripheral circulatory disorders, type II or unspecified type, not stated as uncontrolled
250.71	Diabetes with peripheral circulatory disorders, type I (juvenile type), not stated as uncontrolled
250.72	Diabetes with peripheral circulatory disorders, type II or unspecified type, uncontrolled
250.73	Diabetes with peripheral circulatory disorders, type I (juvenile type), uncontrolled
ICD-9 code	
250.8	Diabetes with other specified manifestations
250.80	Diabetes with other specified manifestations, type II or unspecified type, not stated as uncontrolled
250.81	Diabetes with other specified manifestations, type I (juvenile type), not stated as uncontrolled
250.82	Diabetes with other specified manifestations, type II or unspecified type, uncontrolled
250.83	Diabetes with other specified manifestations, type I (juvenile type), uncontrolled
250.9	Diabetes with unspecified complication
250.90	Diabetes with unspecified complication, type II or unspecified type, not stated as uncontrolled
250.91	Diabetes with unspecified complication, type I (juvenile type), not stated as uncontrolled
250.92	Diabetes with unspecified complication, type II or unspecified type, uncontrolled
250.93	Diabetes with unspecified complication, type I (juvenile type), uncontrolled
581	Nephrotic syndrome
581.0	Nephrotic syndrome with lesion of proliferative glomerulonephritis
581.1	Nephrotic syndrome with lesion of membranous glomerulonephritis
581.2	Nephrotic syndrome with lesion of membranoproliferative glomerulonephritis
581.3	Nephrotic syndrome with lesion of minimal change glomerulonephritis
581.8	Nephrotic syndrome with other specified pathological lesion in kidney
581.81	Nephrotic syndrome with other specified pathological lesion in kidney in diseases classified elsewhere

(*Continued*)

Table S1 (*Continued*)

CPT code	Description
581.89	Other nephrotic syndrome with specified pathological lesion in kidney
581.9	Nephrotic syndrome with unspecified pathological lesion in kidney
582	Chronic glomerulonephritis
582.0	Chronic glomerulonephritis with lesion of proliferative glomerulonephritis
582.1	Chronic glomerulonephritis with lesion of membranous glomerulonephritis
582.2	Chronic glomerulonephritis with lesion of membranoproliferative glomerulonephritis
582.4	Chronic glomerulonephritis with lesion of rapidly progressive glomerulonephritis
582.8	Chronic glomerulonephritis with other specified pathological lesion in kidney
582.81	Chronic glomerulonephritis with other specified pathological lesion in kidney in diseases classified elsewhere
582.89	Other chronic glomerulonephritis with specified pathological lesion in kidney
582.9	Chronic glomerulonephritis with unspecified pathological lesion in kidney
585	Chronic renal failure
585.1	Chronic kidney disease, Stage I
585.2	Chronic kidney disease, Stage II (mild)
585.3	Chronic kidney disease, Stage III (moderate)
585.4	Chronic kidney disease, Stage IV (severe)
585.5	Chronic kidney disease, Stage V
585.6	End stage renal disease
585.9	Chronic kidney disease, unspecified
587	Unspecified renal sclerosis
588	Disorders resulting from impaired renal function
588.0	Renal osteodystrophy
ICD-9 code	
588.1	Nephrogenic diabetes insipidus
588.8	Other specified disorder resulting from impaired renal function
588.89	Other specified disorders resulting from impaired renal function
588.9	Unspecified disorder resulting from impaired renal function
GPI code	
2710101000	Insulin (Regular) Inj 100 Unit/ML
2710101000	Insulin (Regular) Inj 80 Unit/ML
2710101000	Insulin (Regular) Inj 40 Unit/ML
2710102000	Insulin Isophane Inj 40 Unit/ML
2710102000	Insulin Isophane Inj 100 Unit/ML
2710102000	Insulin Isophane Inj 80 Unit/ML
2710103000	Insulin Protamine Zinc Inj 40 Unit/ML
2710103000	Insulin Protamine Zinc Inj 100 Unit/ML
2710104000	Insulin Zinc Inj 40 Unit/ML
2710104000	Insulin Zinc Inj 80 Unit/ML
2710104000	Insulin Zinc Inj 100 Unit/ML
2710105000	Insulin Zinc, Extended Inj 100 Unit/ML
2710105000	Insulin Zinc, Extended Inj 40 Unit/ML
2710106000	Insulin Zinc, Prompt Inj 100 Unit/ML
2710106000	Insulin Zinc, Prompt Inj 40 Unit/ML
2710201000	Insulin Regular (Beef) Inj 100 Unit/ML
2710202000	Insulin Isophane (Beef) Inj 100 Unit/ML
2710203000	Insulin Protamine Zinc (Beef) Inj 100 Unit/ML
2710204000	Insulin Zinc (Beef) Inj 100 Unit/ML
2710205000	Insulin Zinc, Extended (Beef) Inj 100 Unit/ML
2710206000	Insulin Zinc, Prompt (Beef) Inj 100 Unit/ML
2710301000	Insulin Regular (Pork) Inj 500 Unit/ML
2710301000	Insulin Regular (Pork) Inj 100 Unit/ML
2710301000	Insulin Regular (Pork) Inj 40 Unit/ML
2710302000	Insulin Isophane (Pork) Inj 100 Unit/ML
2710303000	Insulin Protamine Zinc (Pork) Inj 100 Unit/ML
2710304000	Insulin Zinc (Pork) Inj 100 Unit/ML
2710306000	Insulin Zinc, Prompt (Pork) Inj 100 Unit/ML
2710307000	Insulin Regular and Isophane (Pork) Inj 100 Unit/ML
2710400200	Insulin Aspart Inj 100 Unit/ML

(*Continued*)

Table S1 (*Continued*)

CPT code	Description
2710400300	Insulin Glargine Inj 100 Unit/ML
2710400500	Insulin Lispro (Human) Inj 100 Unit/ML
2710401000	Insulin Regular (Human) Inj 100 Unit/ML
2710401500	Insulin Regular (Human) Inj Buffered 100 Unit/ML
GPI code	
2710402000	Insulin Isophane (Human) Inj 100 Unit/ML
2710403000	Insulin Zinc (Human) Inj 100 Unit/ML
2710405000	Insulin Zinc, Extended (Human) Inj 100 Unit/ML
2710407000	Insulin Aspart Prot and Aspart (Human) Inj 100 Unit/ML (70–30)
2710408000	Insulin Lispro and Lispro Prot (Human) Inj 100 Unit/ML (25–75)
2710409000	Insulin Isophane and Regular (Human) Inj 100 Unit/ML (50–50)
2710409000	Insulin Isophane and Regular (Human) Inj 100 Unit/ML (70–30)
2710409000	Insulin Regular and Isophane (Human) Inj 100 Unit/ML (30–70)

Abbreviations: CPT, Current Procedural Terminology; GPI, Generic Product Identifier; ICD-9, International Classification of Diseases Ninth revision; Inj, injected.