A Systematic Review of Factors Associated With Utilization of Monitored Anesthesia Care for Gastrointestinal Endoscopy

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Abstract: Utilization of monitored anesthesia care (MAC) for gastrointestinal endoscopy has increased markedly over the past decade, leading to significant additional health care expenditures. However, the extent to which certain patient-, provider-, and facility-level factors lead to MAC utilization is unclear. A systematic review of 13 studies evaluating influential factors associated with MAC utilization for colonoscopy and/or esophagogastroduodenoscopy was conducted. Multiple studies revealed significant increases in MAC utilization since the early 2000s, with substantial regional variation. The most influential patient-related factors associated with MAC utilization include female sex and diagnostic procedural indication. Other patient-related factors with weaker associations or conflicting evidence include older age, comorbidity, higher patient income, and white/non-Hispanic race. The impact of patient substance use and/or prescription medication use has been minimally studied. The strongest provider- and facility-level factors associated with MAC use are a surgeon endoscopist and nonhospital site of service. Other factors with weaker associations include facility endoscopy volume and endoscopist years of experience. Further qualitative and quantitative health services research is needed to better understand the root cause of the rising trend of MAC utilization and to develop policies for encouraging appropriate use of MAC.

Roughly 14 million colonoscopies and 7 million esophagogastroduodenoscopies (EGDs) are performed in the United States annually.[1,2] While these procedures are routinely performed with moderate conscious sedation (with short-acting narcotics and benzodiazepines) administered by endoscopy nurses under the direction of a gastroenterologist, there has been increasing utilization of monitored anesthesia care (MAC) for gastrointestinal endoscopy. MAC frequently utilizes propofol for sedation, which may have a narrower window between moderate and deep sedation, the latter of which necessitates the capability of advanced airway management. Furthermore, involvement of an anesthesiologist

triggers a separate billing code beyond the baseline endoscopy code, leading to billions of dollars in additional annual expenditures.[3] Reviewing the current state of the evidence regarding factors associated with utilization of MAC for gastrointestinal endoscopy represents an important step in better understanding drivers of its increased use in order to encourage value-based utilization of this costly service.

Methods

Data Sources and Searches

This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[4] A systematic literature search for all observational studies and randomized, controlled trials from January 1980 through March 2015 was conducted using 3 citation databases: PubMed, EMBASE, and CINAHL. The year 1980 was chosen as the start date because propofol, the most commonly used agent in MAC, was not used clinically until the 1980s. This date is consistent with the cutoff used in the Cochrane review of outcomes of propofol use.[5] Search terms varied by resource and were comprised of database-specific, controlled vocabulary terms and keywords for the concepts of MAC for gastrointestinal endoscopy. No limits were applied for language or publication type. All searches were run in the English language. Scopus was used for cited reference searching.

Study Selection

Two investigators independently reviewed titles and abstracts of all citations identified by the literature search. Potentially relevant studies were retrieved and reviewed, and the following selection criteria were applied: (1) observational study or randomized, controlled trial primarily examining utilization or factors associated with utilization of MAC for EGD and/or colonoscopy, (2) analysis of more than 10,000 procedures, and (3) original data not duplicated in another abstract or manuscript.

Data Extraction and Quality Assessment

Full-text manuscripts of potentially relevant studies were independently reviewed, and data were abstracted by 2 authors. Potentially relevant non-English articles were translated and included. All potentially relevant articles that were excluded are accounted for in Figure 1 with reasons for exclusion. The following data were abstracted from eligible studies onto standardized data extraction forms by 2 investigators in duplicate and independent fashion: (1) first author; (2) publication year; (3) article type; (4) country of origin; (5) aim/objective; (6) study design; (7) study selection criteria; (8) independent

predictor variables, including those that were significantly associated with MAC utilization; (9) data analysis technique(s); and (10) total number of procedures (and proportion using MAC). Any discrepancy between the reviewers was resolved by a joint re-review of the studies and discussion with the senior author.

Methodologic quality of each study was assessed using the Newcastle-Ottawa scale,[6] recommended by the Cochrane Collaboration.[7] This instrument grades quality on a 0-to-9 scale based on selection, comparability, and outcome/exposure. Discrepancies in quality score were resolved by a joint re-review of the studies and discussion with the senior author.

Data Synthesis and Analysis

Because of significant heterogeneity among studies, quantitative pooling of data was not possible. Therefore, studies were reviewed in a qualitative synthesis, with effect estimates and 95% CI included when available.

Factors Associated With Monitored Anesthesia Care Utilization for Gastrointestinal Endoscopy

After identifying 4014 records through database searching and removing duplicates, 2 reviewers screened 3066 citations, assessed 27 potentially relevant publications, and identified 13 observational studies meeting eligibility criteria (Figure 1). Of eligible observational studies, 7 were manuscripts and 6 were published solely in abstract form. The majority of studies were graded as moderate-to-high quality based on the Newcastle-Ottawa scale (Table).[8-19]

Temporal Factors and Time Trends

Six studies evaluated time trends in MAC utilization for gastrointestinal endoscopy in the United States (Figure 2). Several of these studies examined Medicare claims. In studies of colonoscopy alone, Cooper and colleagues found an increase in MAC use from 8.6% to 35.4% between 2000 and 2009,[13] while Khiani and colleagues (using Surveillance, Epidemiology, and End Results [SEER]-Medicare data) found an increase from 11.0% to 23.4% between 2001 and 2006.[17]

Similar trends were found in non-Medicare populations. In comparing Medicare fee-for-service vs commercially insured patients (using MarketScan databases), Liu and colleagues found that the proportion of MAC cases in a cohort of commercially insured patients increased at a rate similar to that in the Medicare cohort between 2003 and 2009 (Medicare, 13.5%-30.2% vs commercially insured, 13.6%-35.5%).[18] Evaluating claims data from a large US-based commercial insurer (i3 Innovus), Inadomi and colleagues found increased use of MAC for colonoscopy (from
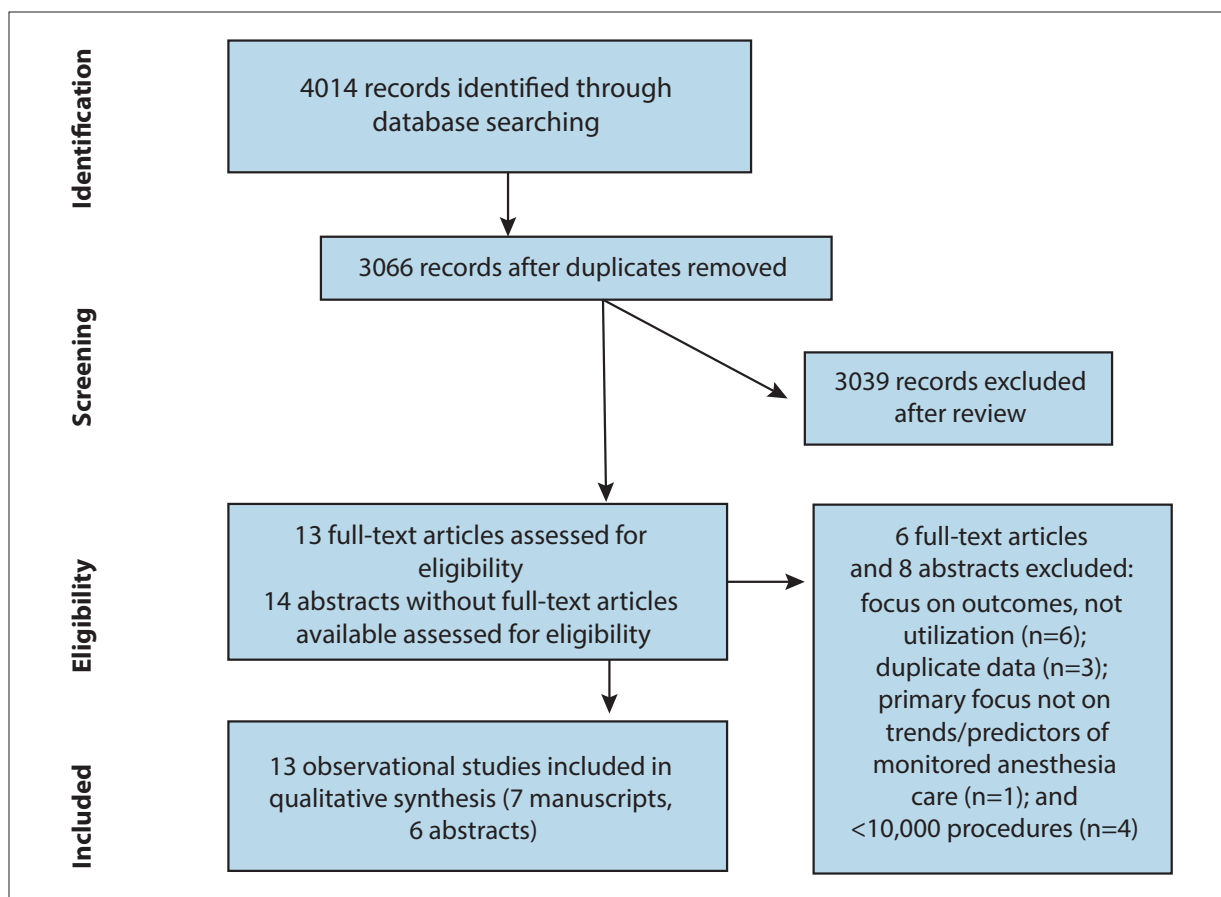
Figure 1. Flow diagram of the search for potentially relevant articles used in this systematic review.

8.8% to 25.0%) and EGD (from 9.8% to 26.0%) between 2003 and 2007.[3] Likewise, in a single-center, US-based study, MAC use increased from 0.4% of colonoscopies in 2003 to 10.0% in 2012 (*P*<.001),[10] while another study showed that deep sedation (MAC not specified) was used in 0.7% of screening colonoscopies in 2001 vs 71.2% in 2011.[12] In addition, MAC use increased from 8.4% to 19.1% between 1993 and 2005 (*P*<.001) among Canadians 20 years or older undergoing colonoscopy under the Ontario Health Insurance Plan (OHIP), a single-payer, government-sponsored health plan.[8]

Geographic Variation
Regional variation in MAC utilization in the United States has been investigated. Evaluation of 2003 Medicare claims revealed significant variation in MAC utilization by state, with the highest use in New Jersey (48.1%), New York (27.9%), and Nevada (26.0%), and the lowest use in Montana (0.1%) and South Dakota (0.2%).[14] Medicare carrier was also significantly associated with MAC utilization, with rates ranging from 0.9% in patients covered by the Arkansas carrier

(adjusted odds ratio [OR], 0.23; 95% CI, 0.21-0.43 vs the Wisconsin carrier) to 35.3% in patients enrolled in Empire Medicare Services in the New York area (adjusted OR, 9.90; 95% CI, 7.92-12.39 vs the Wisconsin carrier).[14] Examining SEER-Medicare data from 2001 to 2006, Khiani and colleagues found significant regional variation in MAC utilization, ranging from 1.6% in San Francisco (OR, 0.18 vs the Iowa carrier) to 57.8% in New Jersey (OR, 15.43 vs the Iowa carrier).[17] This finding of significant regional variation was confirmed by Cooper and colleagues in a study of SEER-Medicare data from 2000 to 2009, with the lowest rates of MAC use in the southwestern and western United States (≤9.0%) and the highest rates of MAC use in the northeastern United States (41.9%; *P*<.001).[13] Substantial regional variation was also observed by Liu and colleagues, with a nearly 4-fold difference between the lowest- and highest-use regions in 2009.[18] In this study, the lowest rate of MAC use was found in the western United States (14% in Medicare vs 12.6% in commercially insured patients), while the highest rate of MAC use was found in the northeastern United States

Table. Summary of Included Studies

Author	Quality Score	Data Source and Procedure Type	Date Range	Total Procedures (n; % MAC)	Time Trend in MAC Use	Predictors of MAC Use
Alharbi et al[8]	7	Ontario Health Insurance Plan Colonoscopy	4/1993-3/2006	1,838,879 (256,799; 14.0%)	8.4% to 19.1%	Hospital site of service (highest in low-volume community hospitals), surgeon endoscopist (hierarchical analysis)
Anderson et al[9]	6	New Hampshire Colonoscopy Registry Colonoscopy	4/2009-3/2011	12,477 (1243; 10.0%)	N/A	Current smokers, Medicaid or uninsured patients, diagnostic indication
Arava-palli et al[10]	8	Endoscopy reports, single-center Colonoscopy	1/2003-10/2012	37,803 (832; 2.2%)	0.4% to 10.0%; adjusted odds of MAC use 1.5 times/year	Female, higher BMI, higher ASA class, diagnostic indication, comorbidities (pulmonary, psychiatric, renal, cerebrovascular)
Campo et al[11]	2	63 public and private hospitals Colonoscopy, EGD	2001	103,731 (15,772; 15.2%)	N/A	Private facilities
Ciofoaia et al[12]	6	Chart review, single-center Colonoscopy	2/2001-10/2011	65,684 (13,645; 20.8%)	0.7% to 71.2%	N/A
Cooper et al[13]	8	SEER-Medicare Colonoscopy	1/2000-11/2009	165,527 (35,128; 21.2%)	8.6% to 35.4%	African American, ASC site of service, geography (northeastern United States)
Dominitz et al[14]	7	Medicare Colonoscopy	2003	328,167 (28,551; 8.7%)	N/A	Patient factors: black, female, diagnostic or surveillance indication, highest-quartile mean income, increased comorbidity; facility factors: surgeon endoscopist, ASC and office-based settings, Medicare carrier, fewer years in practice
George et al[15]	7	Medicare/ commercial insurers Colonoscopy	2010	Unclear (infer >10,000)	Annual utilization of deep sedation 1.3/1000 patients (Medicare), 0.7/1000 (commercial)	N/A
Hoda et al[16]	6	CORI database Colonoscopy	2002-2007	104,868 (3501 deep sedation; 3.3%)	N/A	Older age, community setting

Table continues on the following page.

Table (continued). Summary of Included Studies

Author	Quality Score	Data Source and Procedure Type	Date Range	Total Procedures (n; % MAC)	Time Trend in MAC Use	Predictors of MAC Use
Inadomi et al[3]	8	i3 Innovus (commercial insurer) Colonoscopy, EGD	2003-2007	3688 zip-code observations (17.3% colonoscopy, 18.4% EGD)	8.8% to 25.0% colonoscopy; 9.8% to 26.0% EGD	Northeastern United States, regions with higher mean income, lower unemployment, higher mean age, non-African American, more populated areas, more short-term hospital admissions, higher number of gastroenterologists in regional market, lower number of anesthesiologists in regional market
Khiani et al[17]	8	SEER-Medicare Screening colonoscopy	7/2001-12/2006	16,268 (2798; 17.2%)	11.0% to 23.4%	Surgeon endoscopist, geographic region (highest in New Jersey), white
Liu et al[18]	8	Medicare fee-for-service/ commercial insurers Colonoscopy, EGD	2003-2009	2.2 million Medicare (302,263; 13.7%), 7.0 million commercially insured (1,573,726; 22.5%)	Similar increase in MAC use for commercial vs Medicare patients (13.6%-35.5% vs 13.5%-30.2%) Use in low-risk Medicare patients doubled (12,989-25,069/million)	Geography (highest in northeastern United States)
Vargo et al[19]	7	CORI database Colonoscopy and EGD	1/1998-6/2003	709,514 (14,572 propofol; 2.1%)	N/A	Female, white/non-Hispanic, ASA class III/IV, community setting, colonoscopy

ASA, American Society of Anesthesiologists; ASC, ambulatory surgery center; BMI, body mass index; CORI, Clinical Outcomes Research Initiative; EGD, esophagogastro-duodenoscopy; MAC, monitored anesthesia care; SEER, Surveillance, Epidemiology, and End Results.

(47.5% in Medicare vs 59.0% in commercially insured patients).[18] In a study using i3 Innovus data mapped to zip code, MAC utilization was more common in regions with higher mean income, lower unemployment, higher mean age, more populated areas, areas with more short-term hospitalizations, more gastroenterologists (OR, 1.79; 95% CI, 1.12-2.87 for gastroenterologists/1000 persons), and fewer anesthesiologists (OR, 0.62; 95% CI, 0.54-0.72 for anesthesiologists/1000 persons).[3]

MAC utilization has also been studied internationally. In a Canadian study, a substantial increase in MAC utilization was observed from 1993 to 2005 (8.4%-19.1%; $P<.001$),[8] whereas a survey study of 63 endoscopy

units affiliated with public and private hospitals in Catalonia, Spain reported MAC utilization rates of 7.0% for EGDs and 25.0% for colonoscopies in 2001.[11] No trends in utilization over time were reported.

Patient-Related Factors

Age Evidence of age as a predictor of MAC utilization is mixed. Older age was predictive of MAC use in the following Medicare studies, although the magnitude of this effect was small: Dominitz and colleagues (8.0% MAC <70 years vs 9.2% MAC >80 years; $P<.001$; adjusted OR, 1.04; 95% CI, 0.99-1.09),[14] Cooper and colleagues (20.4% MAC 66-69 years vs 22.2% MAC ≥85 years;
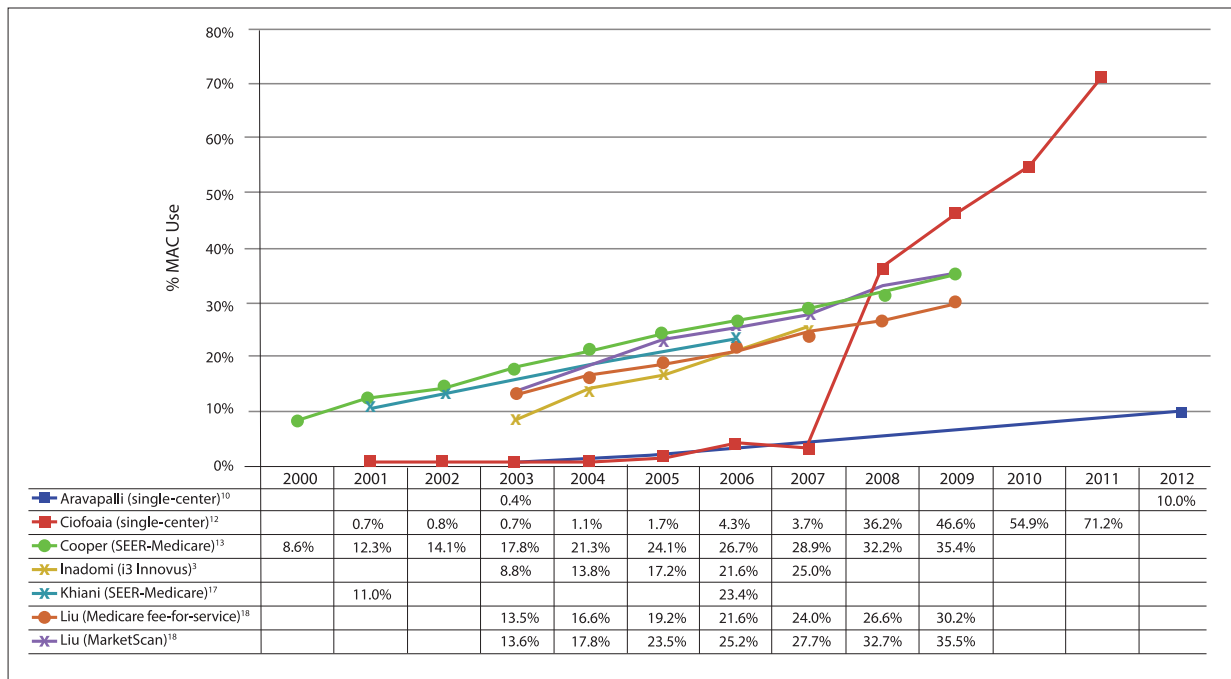
Figure 2. Overall trends in annual monitored anesthesia care (MAC) use for gastrointestinal endoscopy in the United States.

SEER, Surveillance, Epidemiology, and End Results.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Aravapalli (single-center)[10]				0.4%									10.0%
Ciofoaia (single-center)[12]		0.7%	0.8%	0.7%	1.1%	1.7%	4.3%	3.7%	36.2%	46.6%	54.9%	71.2%	
Cooper (SEER-Medicare)[13]	8.6%	12.3%	14.1%	17.8%	21.3%	24.1%	26.7%	28.9%	32.2%	35.4%			
Inadomi (i3 Innovus)[3]				8.8%	13.8%	17.2%	21.6%	25.0%					
Khiani (SEER-Medicare)[17]		11.0%					23.4%						
Liu (Medicare fee-for-service)[18]				13.5%	16.6%	19.2%	21.6%	24.0%	26.6%	30.2%			
Liu (MarketScan)[18]				13.6%	17.8%	23.5%	25.2%	27.7%	32.7%	35.5%			

$P<.001$,[13] and Liu and colleagues (age associated with MAC use in both Medicare fee-for-service and commercially insured).[18] Likewise, in a commercially insured population, adjusted odds of MAC use in patients 45 years or older was 1.71 (95% CI, 1.51-1.94), as compared to younger patients.[3] Older age also was associated with MAC use in a study of Clinical Outcomes Research Initiative (CORI) data (mean age, 61.3 vs 60.8 years for moderate conscious vs deep sedation; $P<.001$), although the magnitude of the effect was similarly small.[16]

In contrast, a study of SEER-Medicare data showed no significant association between age and MAC utilization on unadjusted analysis,[17] and the Canadian study also found no association on hierarchical analysis.[8] Likewise, a study of patients age 40 years or older in the New Hampshire Colonoscopy Registry (NHCR) found no difference in the mean age of patients receiving moderate conscious sedation vs MAC.[9] A single-center study of inpatient and outpatient colonoscopies from 2003 to 2012[10] and a second CORI registry study[19] also found no association between age and MAC utilization.

Race Several studies have examined the association between race and MAC utilization. In some studies, MAC utilization has been higher in white patients or those classified as white/non-Hispanic.[3,17] While African American race was significantly associated with MAC use on univariate analysis (21.7% black vs 17.8% white) in a

study by Khiani and colleagues, African American patients were significantly less likely to have received MAC than their white counterparts after adjusting for confounders (adjusted OR, 0.76; 95% CI, 0.61-0.94).[17] Similarly, Inadomi and colleagues found a slightly lower likelihood of MAC use in African Americans than in whites (OR, 0.94 for African Americans; 95% CI, 0.88-0.99).[3] In contrast, Dominitz and colleagues found greater odds of MAC use in African Americans (adjusted OR, 1.37; 95% CI, 1.22-1.54) than in whites.[14]

Sex Female sex is associated with a slightly increased likelihood of MAC use. Women had marginally greater odds of MAC use than men in the study by Dominitz and colleagues (adjusted OR, 1.05; 95% CI, 1.02-1.08).[14] Female sex was also significantly associated with MAC use in a single-center study of inpatient and outpatient colonoscopies performed in a hospital-based endoscopy unit, but no further details are available in the abstract.[10] Similarly, in a study using CORI data, patients sedated with MAC for colonoscopies and EGDs were also more likely to be female (56.1% MAC vs 46.1% standard sedation; $P<.001$).[19]

Obesity and Obstructive Sleep Apnea An association between higher body mass index (BMI) and MAC utilization was reported in a single-center retrospective cohort study from 2013, but further details were not outlined

in the abstract.[10] However, no association between BMI and MAC use was found in a study of NHCR data (BMI propofol vs other, 28.3 ± 6.0 kg/m² vs 28.1 ± 5.8 kg/m²; P>.05).[9] Obstructive sleep apnea, often present in obese individuals, was more common in Medicare beneficiaries receiving MAC; however, the magnitude of this difference was small (22.9% MAC with obstructive sleep apnea vs 21.2% without; P<.003).[13]

Substance Use and Prescription Medications In a study by Anderson and colleagues, patients receiving MAC were more likely to be current smokers than those receiving non-MAC sedation (12.6% MAC vs 9.1% non-MAC; P<.001).[9] No included studies directly examined the associations with chronic drug or alcohol use, or use of prescription medications that might interfere with standard sedation techniques.

Procedural Factors The extent to which procedure type or indication may predict MAC utilization also has been investigated. CORI data reflected a higher proportion of MAC use for colonoscopies (63.3% MAC vs 51.1% standard sedation; P<.001) than EGDs.[19] A diagnostic procedural indication has been associated with MAC utilization in studies by Anderson and colleagues (14.2% diagnostic vs 12.4% other; P<.001),[9] Aravapalli and colleagues (not further specified in the abstract),[10] and Dominitz and colleagues (adjusted OR, 1.82; 95% CI, 1.68-1.98 for diagnostic indication vs screening).[14]

Income and Insurance Status Higher mean patient income was associated with increased MAC use in a Medicare study by Dominitz and colleagues[14] (adjusted OR, 1.52; 95% CI, 1.36-1.70, for highest vs lowest quartile mean income) and in a study of commercially insured patients by Inadomi and colleagues[3] (OR, 1.49; 95% CI, 1.33-1.67, per increment of $100,000 estimated income). In an unadjusted analysis, a SEER-Medicare study found greater odds of MAC use in patients with higher income (unadjusted OR, 1.79; 95% CI, 1.58-2.03 for income >$65,523 using income <$34,795 as reference), but after adjusting for confounders, the opposite effect was seen (adjusted OR, 0.51; 95% CI, 0.58-0.81 for income >$65,523 using income <$34,795 as reference).[17]

The insurance status of a patient may also predict MAC use, as shown by the NHCR study in which a higher proportion of patients with Medicaid or no insurance received propofol for endoscopic sedation as compared with privately insured patients (P<.001).[9]

Comorbidities A variety of measures have been used to investigate the association between patient comorbidity and MAC utilization, including the American Society of Anesthesiologists (ASA) Physical Status classification system, previously validated comorbidity indexes such as Charlson/Deyo[20] and Elixhauser,[21] and the presence of certain individual comorbidities.

A study by Vargo and colleagues found that ASA class I/II patients represented a higher proportion of patients receiving standard sedation than MAC (77.5% vs 64.3%, respectively; P<.001).[19] Higher ASA class and the presence of pulmonary, psychiatric, renal, and cerebrovascular comorbidities were found by Aravapalli and colleagues to be associated with increased MAC use on multivariable logistic regression, but specific details were not reported in the study abstract.[10] Nonetheless, a study by Liu and colleagues found that the volume of procedures performed with MAC in low-risk Medicare patients (defined as ASA class I/II imputed from available data) increased substantially between 2003 and 2009 (13,989/ million enrollees in 2003; 95% CI, 13,870-14,100 vs 25,069/million in 2009; 95% CI, 24,720-25,270).[18] However, this study did not specifically address whether the increased use could be due to a concomitant increase in total procedures during this time period.[18]

Several studies also have demonstrated associations between higher comorbidity scores and MAC utilization. Dominitz and colleagues found increased MAC utilization in patients with a Charlson/Deyo comorbidity score greater than 3 vs 0 (10.1% vs 8.2%; P<.001).[14] In contrast, Khiani and colleagues found a significant association between a higher Elixhauser comorbidity score and MAC use on univariate analysis, although this association did not persist after adjusting for confounders (OR for score >3 vs 0: unadjusted OR, 1.25; 95% CI, 1.07-1.45; adjusted OR, 1.15; 95% CI, 0.96-1.37).[17]

Provider-Related Factors
The impacts of provider endoscopy volume, specialty, and age/level of experience on MAC utilization also have been studied. Annual provider endoscopy volume was not significantly associated with MAC use in Medicare data. In the single study directly evaluating the role of endoscopist experience, endoscopists with more than 25 years of experience were less likely to use MAC as compared with endoscopists with 10 years or less of experience (adjusted OR, 0.80; 95% CI, 0.68-0.94).[14]

Likewise, the presence of a surgeon endoscopist (as compared to a gastroenterologist) was found to be predictive of MAC utilization in studies by Dominitz and colleagues (colorectal surgeon: adjusted OR, 1.89; 95% CI, 1.50-2.37 vs general surgeon: adjusted OR, 1.53; 95% CI, 1.18-1.98),[14] Khiani and colleagues (surgeon: adjusted OR, 2.80; 95% CI, 2.40-3.27),[17] and Alharbi and colleagues (surgeon: adjusted OR, 1.7; 95% CI, 1.1-2.6, which persisted on hierarchical analysis).[8]

Facility-Related Factors

The site of service may influence MAC utilization, although findings have been inconsistent. In a hierarchical analysis, Alharbi and colleagues found 5-times greater odds of receiving MAC for colonoscopy at low-volume community hospitals in Ontario, Canada (OR, 4.9; 95% CI, 4.4-5.5) as compared to their high-volume counterparts.[8] This study also found significantly higher MAC use when endoscopy was performed in a hospital vs non-hospital setting.[8] In contrast, the majority of US studies have found significantly higher MAC use in nonhospital settings, including private facilities,[11] ambulatory surgery centers (ASCs),[13,14] and office-based or community settings.[14,19] As compared to a hospital outpatient site of service, Dominitz and colleagues found greater odds of MAC use for colonoscopies performed in ASCs (adjusted OR, 1.81; 95% CI, 1.60-2.06) and office-based settings (adjusted OR, 2.66; 95% CI, 2.14-3.30).[14] These findings were confirmed by Cooper and colleagues (26.5% ASC vs 19.1% hospital; $P<.001$).[13] In a survey of endoscopic practice patterns in Spain, endoscopic sedation was more frequently administered by an anesthesiologist in private vs public settings (EGD, 25% vs 2%; colonoscopy, 57% vs 9%; $P<.001$).[11]

Discussion

Variation in utilization of medical services has come under increased scrutiny in recent years due to ballooning health care costs, greater recognition of overuse/misuse and related patient harms, and increased calls for value-based utilization. The greatest variation in utilization of medical services is often seen with procedures or interventions for which the risks vs benefits are less clear, leading to greater discretionary decision-making by the ordering physician.[22] In the case of anesthesia assistance for gastrointestinal endoscopy, a multitude of factors may drive decision-making regarding sedation triage, including patient-, provider-, and facility-level factors, and regional payer factors influencing reimbursement. Effective marketing by anesthesiologists may represent another potential driver.[23] American Society for Gastrointestinal Endoscopy guidelines from 2008 suggest that use of MAC for average-risk patients undergoing routine upper and lower endoscopic procedures is not cost-effective and recommend considering MAC for patients undergoing complex endoscopic procedures, patients in whom there is anticipated intolerance of standard sedatives, or patients with severe comorbidities or potential for airway compromise.[24] A 2009 multisociety position statement similarly questions the benefit of MAC in low-risk patients with no comorbidities undergoing routine gastrointestinal endoscopy.[25] However, these guidelines

still leave much to the interpretation and discretion of the provider. In fact, there is evidence that roughly two-thirds of monitored anesthesia is used in low-risk patients.[13]

Potential benefits of MAC include enhanced monitoring of patients with severe cardiopulmonary comorbidities and/or potential for airway compromise, improved endoscopy unit efficiency as measured by shorter recovery and discharge times, and increased patient satisfaction.[5] However, there is also the potential for clinical harm, including increased risk of 30-day complications[13,26] and the economic implications of involving an additional physician in the procedure. Utilization of MAC for routine endoscopic sedation resulted in additional national expenditures of $129 million for Medicare and $945 million for commercially insured patients in 2009.[17]

As demonstrated by multiple studies above, there has been a marked increase in the use of MAC for gastrointestinal endoscopy since the early 2000s. In recent years, insurers have attempted to curtail this utilization by adopting policy language defining criteria for medically necessary use.[27,28] Increased MAC utilization in the Medicare population (from <10% to >35% since the early 2000s) has been attributed primarily to economic drivers. However, this conclusion seems premature, as there has been little investigation into utilization patterns in integrated health care delivery systems in which economic drivers may be less influential or may discourage rather than incentivize utilization. The study by Alharbi and colleagues is therefore informative, as it reveals similar increases in MAC utilization in patients covered by OHIP (a government-sponsored health plan in Canada in which regional payer influences observed in US markets are not present).[8] Specifically, this study suggests that while economic drivers may certainly be contributing to increased MAC use, influential noneconomic drivers likely exist as well. Other potential factors that have been inadequately explored include the impact of increasing prescription opioid and benzodiazepine use and changes in patient expectations regarding their sedation experience.

The strongest patient-level factors associated with MAC use are female sex and diagnostic procedural indication. Regarding provider- and facility-level factors, the presence of a surgeon endoscopist and a nonhospital site of service are most strongly associated with MAC utilization. Differences in point estimates among Medicare studies are likely due to heterogeneity in procedure type and time periods studied, and the specific confounding factors adjusted for in the analysis. Geography also appears to be a significant predictor, thought to be due to regional payer influences or differences in the regional provider culture. Increased demand for procedures in population-dense regions such as the northeastern United States could theoretically drive providers to use more MAC in order
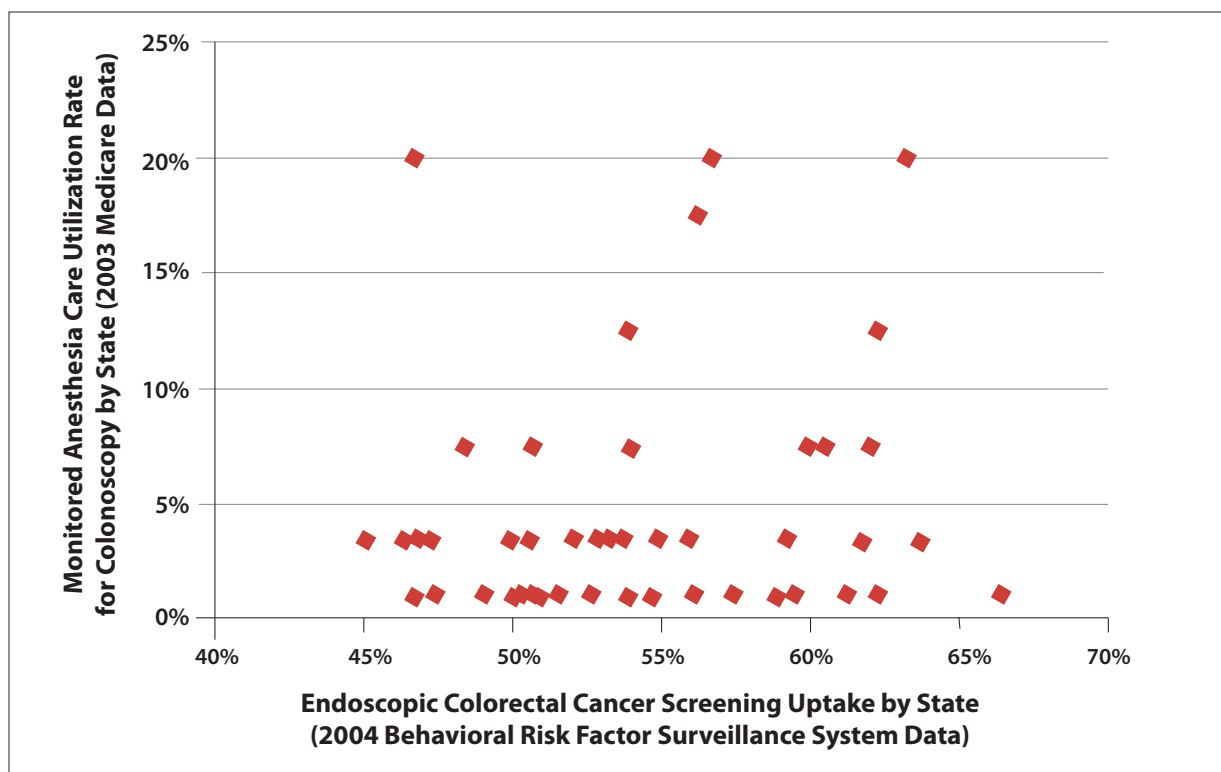
Figure 3. No significant correlation was found between state-level monitored anesthesia care utilization (based upon 2003 Medicare data) and endoscopic colorectal cancer screening prevalence (based upon 2004 Behavioral Risk Factor Surveillance System data).

to enhance endoscopy unit efficiency and increase procedural access. However, it is worth noting that high rates of MAC utilization have also been seen in states that have significantly lower population densities, such as Nevada.[14] State-level trends in MAC utilization rates similarly are not significantly correlated with increased endoscopic colorectal cancer screening prevalence and related effects on endoscopic access and utilization (Pearson correlation coefficient = 0.17; P=.86; Figure 3).[14,29]

Increased MAC utilization in nonhospital settings likely reflects the influence of financial incentives for anesthesiologist involvement in ASCs and office-based settings. Concerns regarding patient satisfaction and endoscopy unit efficiency also may contribute to this phenomenon. Factors driving increased MAC use by surgeon endoscopists vs gastroenterologists are less clear, but may reflect the lower-volume endoscopy practices of surgeons, lack of specific training in administration of endoscopic sedation, or use of anesthesiologist-administered sedation for nonendoscopic procedures performed in continuity. Understanding these nuances may ultimately require a mixed-methods study, which would enable investigators to elucidate system-level factors that influence the decision-making of providers from different specialties and from high- and low-utilization facilities.

The association between patient comorbidity and MAC use is weak, suggesting that considerations other than patient-level procedural risk strongly influence choice of sedation. In addition, studies support a weak to nonsignificant association between age and MAC use. Evidence regarding an association between higher patient income and MAC use is mixed, with Medicare studies showing conflicting results on adjusted analysis,[14,17] and data from the NHCR study demonstrating increased MAC use in Medicaid or uninsured patients, the majority of whom are presumably low-income.[9] While evidence is conflicting regarding an association with race, studies concur that female sex is associated with MAC use.[10,14,19] This may reflect the higher prevalence of functional abdominal pain in women or a history of pelvic surgery that may portend a prolonged and technically challenging endoscopic procedure.[30] While patient substance use and chronic narcotic or benzodiazepine use has anecdotal relevance to sedation decisions, this association has not been widely investigated in large-scale studies.

Limitations of this systematic review include significant heterogeneity among studies precluding meta-analysis, and the possibility of incomplete retrieval of relevant studies.

Conclusion

MAC utilization for gastrointestinal endoscopic sedation has increased markedly over the past decade, leading to significant additional health care expenditures. MAC use appears to be driven by a complex interplay of economic and noneconomic factors, rather than being easily explained by financial drivers alone. While payment reforms may effectively reduce financial drivers, it is important to better understand significant noneconomic drivers of MAC utilization in order to effectively design interventions to encourage appropriate utilization of MAC. Further research examining utilization patterns and predictors in integrated health care delivery systems, which are not as heavily influenced by financial incentives, is overdue.

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