



## REVIEWS

# An Estimate of the US Rate of Overuse of Screening Colonoscopy: a Systematic Review

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**BACKGROUND:** This study aims to assess the rate at which screening colonoscopy is performed on patients younger or older than the age range specified in national guidelines, or at shorter intervals than recommended. Such non-indicated use of the procedure is considered low-value care, or overuse. This study is the first systematic review of the rate of non-indicated completed screening colonoscopy in the USA.

**METHODS:** PubMed and Embase were queried for relevant studies on overuse of screening colonoscopy published from January 1, 2002, until January 23, 2019. English-language studies that were conducted for screening colonoscopy after 2001 for average-risk patients were included. Studies must have followed national guidelines for detecting rates of overuse. We followed methods outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and the reporting recommendations of the Meta-analysis of Observational Studies in Epidemiology group (MOOSE).

**RESULTS:** A total of 772 papers were reviewed for inclusion; 42 were reviewed in full text. Of those reviewed, six studies met eligibility criteria, including a total of 459,503 colonoscopies of which 242,756 were screening colonoscopies. The rate of overuse ranged credibly from 17 to 25.7%.

**DISCUSSION:** This study demonstrates that screening colonoscopy is regularly performed in the USA more often, and in populations older or younger, than recommended by national guidelines. Such overuse wastes resources and places patients at unnecessary risk of harm. Efforts to reduce non-indicated screening colonoscopy are needed.

**KEY WORDS:** overuse; screening colonoscopy; low-value care; harms.

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## INTRODUCTION

For more than two decades, the United States Preventive Services Task Force (USPSTF) and other national organizations have recommended screening for colorectal cancer,<sup>1,2</sup> with either a stool-based or direct visualization test.<sup>3</sup> While screening colonoscopy poses the risk of serious harm, the USPSTF concluded this risk is outweighed by potential benefits, depending upon age, risk factors, and prior colonoscopic findings, and if performed at the recommended schedule for average-risk adults between 45 and 75 years old.<sup>1</sup> Guidelines issued by the U.S. Multi-Society Task Force are similar to those of the USPSTF.<sup>2</sup>

Screening colonoscopy is often performed on patients younger or older than the age range specified in national guidelines, or at shorter intervals than recommended. Such non-indicated use of the procedure is considered low-value care, or overuse. Several studies have reported on the incidence of non-indicated colonoscopy in the USA,<sup>5–8</sup> typically within specific demographic or regional groups. A recent systematic review and meta-analysis found that endoscopists recommend screening colonoscopy at shorter intervals than suggested by guidelines to nearly half of their patients.<sup>9</sup> However, this systematic review did not examine the actual rate at which inappropriate colonoscopies are performed. This study is the first systematic review of the rate of non-indicated screening colonoscopy performed within the USA.

This study reviews rates of completed, non-indicated colonoscopy in order to estimate a credible range of the rate of actual overuse. In a future study, the authors plan to use the results of this systematic review, together with a parallel systematic review of severe harms from the procedure, to estimate national rates of harm from inappropriate screening colonoscopy.<sup>10</sup>

## METHODS

We conducted a systematic review of the overuse of optical colonoscopy for the screening of colorectal cancers. We followed methods outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and

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the reporting recommendations of the Meta-analysis of Observational Studies in Epidemiology group (MOOSE).<sup>11,12</sup>

## Data Sources

Eligible trials were identified by searches of PubMed and Embase. Studies published from January 1, 2002, to January 23, 2019, were included in the searches. Search strategies are included in Supplement 1.

## Eligibility Criteria

Studies evaluating overuse were considered eligible if the study: (1) was performed in a standard endoscopy suite in the USA; (2) used US national guidelines including the USPSTF and the multi-society task force to define overuse in a US sample; (3) enrolled patients after 2002, when the USPSTF began recommending colonoscopy for colorectal cancer (CRC) screening (4) reported on completed screening colonoscopies; and (5) included asymptomatic patients at average risk of developing colon cancer. Studies were excluded if they enrolled patients with high-risk classification such as personal history of CRC, inflammatory bowel disease, signs of possible CRC, and family history of CRC because the recommendations for screening such patients are different from those for patients of average risk. Studies including only surveillance colonoscopies alone were also excluded as were studies that did not quantify estimates of overuse and were written in a language other than English. (6) Repeat colonoscopies which occurred less than 6 months after the initial colonoscopy were excluded as these occurred most likely due to inadequate bowel prep, and should not be labeled as inappropriate.

## Study Identification

Two independent investigators (J.F. and A.H.) screened articles by title and abstract using predefined inclusion and exclusion criteria and a standardized data form. If the article did not meet inclusion criteria based on the abstract, the full text was not reviewed. The inclusion of full text was decided by consensus, and a third reviewer (K.L.) independently resolved all cases of discordance. Inter-reviewer reliability was assessed and reported using Cohen's kappa statistic.

## Data Extraction and Outcomes

Paired reviewers (J.F., A.H., K.L., S.B.) independently abstracted results from each article in duplicate. The included data were as follows: study characteristics, patient characteristics, population analyzed, definition of overuse, total screening colonoscopies identified, and incidence of non-indicated screening colonoscopy.

The primary outcome for overuse analysis was the percentage of total screening colonoscopies not adherent with national guidelines. This included colonoscopies performed in patients younger or older than those specified by the prior

USPSTF guidelines available when studies were performed (colonoscopy performed in patients over 75 years old without indication; and screening colonoscopies completed on patients with a life expectancy of less than 10 years), and those performed more often than recommended (screening colonoscopy completion less than 9 years after normal screening colonoscopy).

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## Data Synthesis and Analysis

Based on the degree of methodological heterogeneity and  $I^2$  among included studies, a narrative synthesis was deemed more appropriate than meta-analysis; therefore, no data were pooled. Instead, we offer a credible range for an estimate of overuse based on studies reporting the lowest and highest rates. To provide a consistently defined rate of overuse across studies, we calculated the total number of non-indicated colonoscopies per total number of screening colonoscopies performed for all studies meeting inclusion criteria.

## Risk of Bias Assessment

Each article was reviewed in full by two authors (SB, JF, AH, KL). There is no standardized risk of bias assessment tool appropriate for overuse studies. Therefore, we used the following parameters to evaluate study quality: study design (retrospective case-control, case-series, cohort), data collection (manual chart review, EHR query), definition of overuse (consistent with national guidelines or not consistent), and how the data were analyzed.

## RESULTS

Of 772 citations, 730 articles were excluded based on title and abstract. Inter-reviewer reliability as assessed by Cohen's kappa was 0.7 ("substantial" agreement). Forty-two studies were reviewed in full text. Of these, one was removed based on non-English language, eleven were removed based on study design, seven were removed based on population studied, and seventeen did not report on overuse (Fig. 1). Six studies met eligibility criteria, including a total of 459,503 colonoscopies of which 242,756 were screening colonoscopies (Table 1).<sup>(5-8,13,14)</sup> Studies ranged in sample size from 1,027 to 88,754

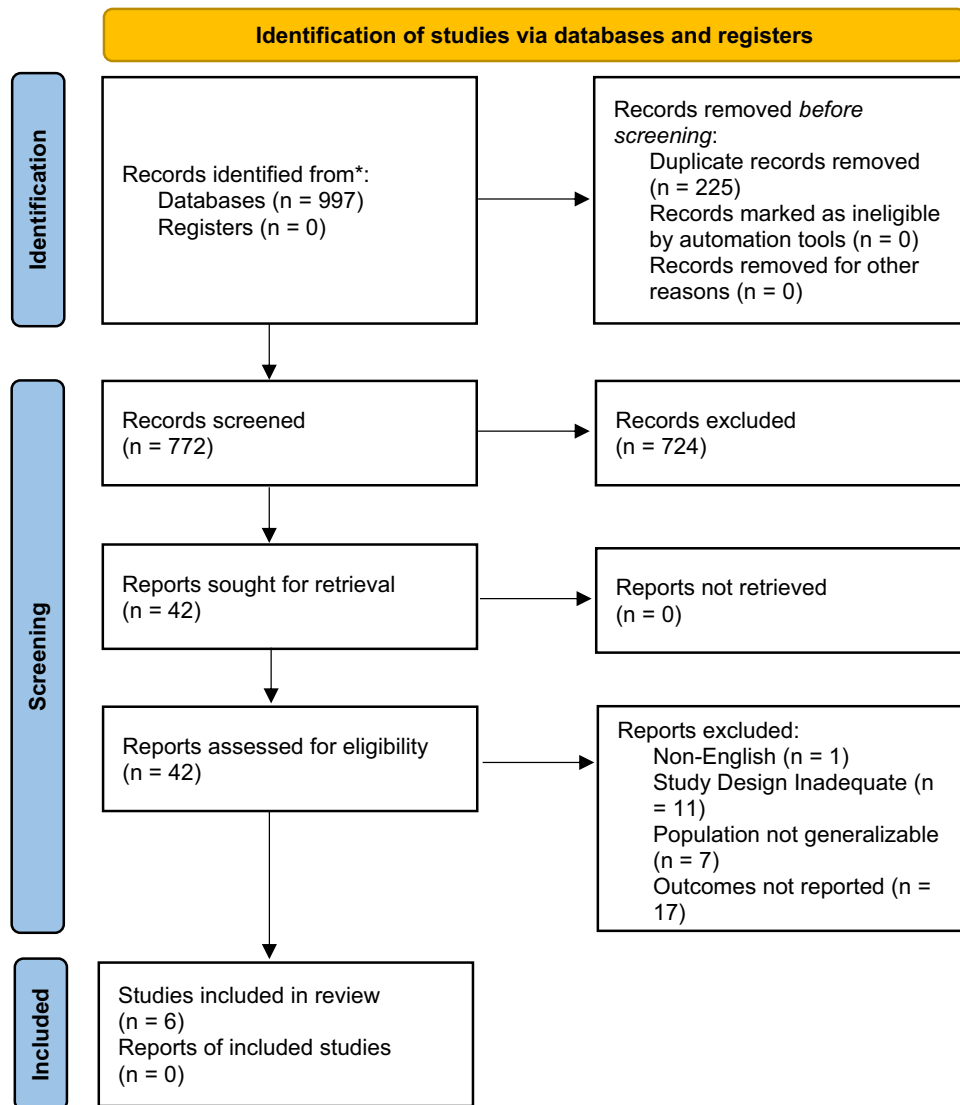


Figure 1 PRISMA 2020 diagram of overuse studies queried from two databases, resulting in 6 eligible articles.

screening colonoscopies and patients ranged in age from under 40 to 102 years. Reported data to calculate median or mean age were not available. Five studies included national samples: three from Medicare and two from the Veterans Health Administration. Two studies included local samples: one used nationwide Medicare data and also included a detailed examination of 100% of Texas Medicare beneficiaries, while another examined colonoscopies performed within a large private health system within Massachusetts (Table 1).

All studies excluded patients at high risk for CRC. All studies other than Murphy et al.<sup>6</sup> excluded cases potentially representing diagnostic colonoscopies (Table 2). Studies specifically identified exclusion criteria to avoid misclassifying diagnostic colonoscopies: three studies excluded 12 symptoms, diagnoses, and/or prior procedures<sup>8,13,14</sup> and Saini et al.<sup>7</sup> excluded based on 25 criteria.

Methodologically, Sheffield et al.,<sup>14</sup> Mittal et al.,<sup>8</sup> and Goodwin et al.<sup>13</sup> identified screening colonoscopies and exclusion criteria via claims data using ICD-9 and CPT codes.

Murphy et al.<sup>6</sup> used a combination of CPT and manual medical record review for data collection. Kruse et al.<sup>5</sup> and Saini et al.<sup>7</sup> used an electronic health record algorithm to identify screening colonoscopies; in addition, Saini et al.<sup>7</sup> used the algorithm to identify screening colonoscopy overuse. The electronic algorithm of Kruse et al.<sup>5</sup> had previously been demonstrated to identify screening colonoscopy with a sensitivity of 88% and specificity of 96%, when compared to manual review. To evaluate their algorithm, Saini et al.<sup>7</sup> performed a manual review of 3,000 colonoscopies; they found their algorithm had a sensitivity of 20% for identifying overuse of screening colonoscopy and specificity of 97%.

All five studies that examined early repeat colonoscopy defined this as colonoscopy performed less than 9 years after prior negative screening colonoscopy. Three studies used an observation period of time following a negative index colonoscopy; Murphy et al.<sup>6</sup> followed patients 6 years; Goodwin et al.<sup>13</sup> followed for 5–7 years, while Kruse et al.<sup>5</sup> collected data on index colonoscopy over a 9-year period, with

Table 1 Overuse Study Characteristics

Study	Year	Patient age	Setting	Data collection method	Study type	Years observed between colonoscopy	Total screening colonoscopies	Overuse criteria
Kruse <sup>22</sup>	2014	50–65	Academically Affiliated Clinics in Massachusetts	An algorithm-based EHR, using diagnostic, and procedure codes	Early repeat colonoscopy after index exam	1–9 years	1,484	Repeat colonoscopy performed without indication
Goodwin <sup>40</sup>	2011	> 66	Medicare 5% National Representative	Claims data using ICD-9 and CPT codes	Early repeat colonoscopy after index exam	5–7 years	19,213*	Repeat colonoscopy performed without indication
Mittal <sup>41</sup>	2014	> 65	Medicare 5% National Representative	Claims data using ICD-9 and CPT codes	Cross-sectional identification of screening colonoscopy	N/a	57,597	Colonoscopy performed on patients with less than 10 years life expectancy †
Murphy <sup>21</sup>	2016	50–64	Veterans Affairs Health Care System	CPT codes and manual medical record review	Early repeat colonoscopy after index exam	5–6 years	1,027	Repeat colonoscopy performed
Saini <sup>23</sup>	2016	> 18	Veterans Affairs Health Care System	Abstraction algorithm-based on EHR ICD-9 and CPT codes	Cross-sectional identification of screening colonoscopy	9 years	88,754	Screening colonoscopy performed without indication; earlier than recommended, or within 6 months of negative FOBT, or in patients with less than 6-month life expectancy
Sheffield <sup>42</sup>	2013	> 70	Medicare 100% Texas Claims	Claims data using ICD-9, HCPCS, and CPT codes	Cross-sectional identification of screening colonoscopy	9 Years	74,681	Screening colonoscopy earlier than recommended without clear indication in patient over 70–75 years old or if greater than 76 years old without diagnostic indication

\* Calculated from data presented within the study

† Using sex-specific model combining age and Elixhauser comorbidity index<sup>41</sup>

repeat screening colonoscopies identified during the same period. Saini et al.<sup>7</sup> and Sheffield et al.<sup>14</sup> were cross-sectional studies and retrospectively identified colonoscopically normal screening colonoscopies in the 9 years prior to index colonoscopy (see Table 1).

The studies identified inappropriate screening colonoscopies using different exclusion criteria (see Table 2) and different methodologies, with various definitions of overuse. This resulted in different practical definitions of overuse. Murphy et al.<sup>6</sup> and Goodwin et al.<sup>13</sup> reported overuse as the total incidence of non-indicated colonoscopy per number of index screening colonoscopies with negative results as the denominator. These studies reported a rate of overuse of 16.4% and 23.5% respectively. Kruse et al.<sup>5</sup> reported overuse as the number of non-indicated repeat colonoscopies as the numerator, and the total number of repeat colonoscopies as the denominator, finding an overuse rate of 88%. Mittal et al.<sup>8</sup> evaluated screening colonoscopy overuse by determining the percentage of colonoscopies performed on patients over the

age of 65 with less than 10-year life expectancy for an overuse rate of 24.8%. Sheffield et al.<sup>14</sup> reported overuse as the percentage of screening colonoscopies performed earlier than recommended as the numerator, with total screening colonoscopies as the denominator, and found a rate of probable overuse of 18.9%. Saini et al.<sup>7</sup> calculated overuse in a manner similar to Sheffield et al.,<sup>14</sup> but in addition to earlier than recommended screening colonoscopy, they also considered inappropriate screening colonoscopies ( patients < 40 years, > 85 years, life expectancy of less than 6 months, colonoscopy performed < 6 months after negative fecal occult blood test). They found a rate of probable overuse of 17%. Factors associated with increased rates of overuse were inconsistent across studies, except for follow-up recommendation adherence to guidelines, which both Kruse et al. and Murphy et al. identified guideline non-adherent follow-up recommendations to be associated with statistically significant increases in rates of overuse. Rates of overuse by patient characteristics can be found in Table 3.

Table 2 Study Exclusion Criteria

Study	Kruse	Goodwin	Mittal	Murphy	Saini	Sheffield
Exclusion criteria						
All exclusion criteria identified in record in X2 months prior					X	
Exclusion criteria of high risk for CRC in X2 months prior		X			X	
Exclusion criteria of high risk for CRC in X0 years prior				X		
Exclusion criteria of high risk for CRC in Chart review	X					
All exclusion criteria examine in 3 months prior						
Symptoms, diagnosis procedures on all claims data indicating diagnostic colonoscopy in 3 months prior		X	X			X
Excluded colonoscopies with symptoms listed by endoscopist for indication	X					
Exclusion criteria of high risk for CRC in X2 months prior				X		
No clear exclusion criteria on repeat colonoscopies						
High risk for CRC diagnosis						
Hx of CRC	X*	X	X	X‡	X	X†
Inflammatory bowel disease		X	X		X	
Familial polyposis syndromes		X				
Colectomy					X	
Colon polyps					X	
Fam Hx of CRC		X	X		X	X
Symptoms, diagnosis, or procedures						
Barium enema		X	X			X
Abdominal CT scan		X	X			X
Anemia		X	X		X	X
GI bleeding		X	X		X	X
Constipation		X	X		X	X
Diarrhea		X	X		X	X
Abdominal pain		X	X		X	X
Abdominal distention					X	
Abdominal swelling					X	
Iron-deficiency anemia					X	
Ischemic bowel disease		X	X			X
Anorexia					X	
Bowel obstruction					X	
Change in bowel habits		X	X		X	X
Fecal incontinence					X	
Heme-positive stool					X	
Hemorrhage of rectum/anus					X	
Nausea/vomiting					X	
Weight loss		X	X		X	X
Hx of colon polyps					X	
Diverticulitis with hemorrhage					X	
Diverticulosis with hemorrhage					X	
Colitis radiation					X	
Intussusception					X	
Paralytic ileus					X	
Megacolon					X	
Irritable colon					X	
Colonoscopy performed during hospitalization					X	
Irritable bowel syndrome		X	X			X
Hemorrhoid		X	X			X
Total number of exclusions	n/a	12	12	n/a	25	12

\*Kruse et al. did not exclude the family history of CRC; however, they repeated the analysis with and without patients with family history and it did not alter the analysis

†Sheffield et al. included those with family history of CRC; however, they labeled early repeat colonoscopy in those with a family history as appropriate, and therefore, family history of CRC was excluded from the overuse group

‡Murphy et al. did not specifically exclude family hx of CRC, but their sample was a cohort of patients taken from a previous study<sup>31</sup> which did exclude those with a family history of CRC

To make the rate of overuse comparable between studies, all rates were converted to a consistently defined rate of overuse, defined as the total number of non-indicated colonoscopies per total number of screening colonoscopies performed. Three of the six studies had used this definition: Saini et al., Sheffield et al., and Mittal et al., with corresponding overuse rates of 17%, 18.9%, and 24.8% respectively. While the three additional studies calculations were made using data reported in the study for Goodwin et al., Murphy et al., and

Kruse et al., with corresponding overuse rates of 19%, 20.3%, and 25.7% respectively.

### Credible range of screening colonoscopy overuse

The credible range of the rate of overuse of screening colonoscopy was 17%<sup>7</sup> to 25.7%<sup>5</sup> (Table 4). At the low end of the credible range, the rate of 17.0% found by Saini et al.<sup>7</sup> is likely an underestimate of the true rate of overuse. We believe this to be the case due to the practice location in Saini et al.,<sup>7</sup>



**Table 3 Rates of Overuse by Patient Characteristics**

	Kruse et al. <sup>5</sup>	Goodwin et al. <sup>13</sup>	Mittal et al. <sup>8</sup>	Murphy et al. <sup>6</sup>	Saini et al. <sup>7</sup>	Sheffield et al. <sup>14</sup>
Study-reported overuse of screening colonoscopy (different overuse definitions used preclude comparability across studies)	88%	23.50%	24.80%	16.4%	17%	18.90%
Patient characteristics						
Sex						
Male	88%	26%	32%	16.6%		21.2%
Female	89%	21.6%	17.6%	15.1%		17.1%
Age						
< 40					8%	
40–49						
50–59	86%					
60–65	89%					
66–69		28%				
66–74			5.9%			
70–74		26.6%				7.9%
75–79		20.7%				
76–85			59.5%			31.7%
> = 80		10.8%				
> = 86			100%		1%	17.3%
Race						
White		23.6%	24.9%	17.7%		19.2%
Black		21.6%	23.2%			16%
Hispanic			24.8%			14.2%
Other			22.3%	13.1%		17.7%
No. of comorbidities						
0		21.7%				23.6%
1		26.2%				22.3%
2		23.6%				20.5%
≥ 3		22%				12.3%
Follow-up recommendation						
Adherent	76%			10.1%		
Non-adherent	95%			30%		
Region						
New England		22.7%				
Northeast				25.6%		
Middle Atlantic		29.3%				
East North Central		24.5%				
Midwest				14.9%		
West North Central		25%				
South Atlantic		21.9%				
East South Central		22.8%				
South				13.5%		
West South Central		22%				
Mountain Pacific		19.9%				
West				19.8%		
Rural/urban						
Metropolitan		24%	25.1%			19.4%
Non-metropolitan		22.2%	23.8%			16.9%
Rural		21.4%	23.9%			18.1%
Place of service						
Office		26.9%				22.5%
Hospital		23.3%				16.2%
Ambulatory center		23.4%				22.6%
Education						
Q1		24.5%	24.6%			21.8%
Q2		24.5%	25.9%			20%
Q3		22.6%	24.7%			18.6%
Q4		22.2%	24%			15.3%
Colonoscopist specialty						
Gastroenterologist		23.6%		15.3%		18.8%
Generalist		20.6%		18.3%		16.5%
Surgeon		23.5%		17.8%		20.2%
Other		27.3%		19.9%		14.1%

\*For rates of overuse with a consistent definition of overuse see Table 4

their exclusion criteria, overuse definition, and data collection methods. Saini et al.<sup>7</sup> was performed in the VA system, which is known to represent a lower level of overuse generally, as the VA system has reduced rates of many unnecessary interventions.<sup>15</sup> The overuse definition and data collection methods in Saini et al.<sup>7</sup> used a methodology designed to be

highly specific at the cost of sensitivity, ensuring their estimate of overuse would not overestimate but rather would underestimate the true rate. Saini et al.<sup>7</sup> contained the most stringent exclusion criteria of all 6 studies, to ensure no diagnostic colonoscopies would be incorrectly counted as overuse, and their stringent exclusion criteria likely categorized many

**Table 4** Calculated Rate of Overuse of Screening Colonoscopy\*

Study	Total screening colonoscopies	Incidence of screening colonoscopy overuse	Screening colonoscopy overuse rate
Kruse et al. <sup>5</sup>	1,484	382	25.70%
Goodwin et al. <sup>13</sup>	19,213 †	3,656	19.0%
Mittal et al. <sup>8</sup>	57,597	14,284	24.80%
Murphy et al. <sup>6</sup>	1,027	208	20.30%
Saini et al. <sup>7</sup>	88,754	15,088	17%
Sheffield et al. <sup>14</sup>	74,681	14,115	18.90%

\*Rates calculated using data from papers and a single definition of overuse

† Data obtained from direct correspondence with the author

inappropriate screening colonoscopies as appropriate diagnostic colonoscopies. Likewise, their definition of overuse, likely led them to count many low-value screenings as appropriate, including exams in patients at average risk between ages 40 and 45 and those over 75 with less than 10-year life expectancy. Both populations of patients are not considered appropriate candidates for screening by the USPSTF guidelines.<sup>2,4</sup> The data collection method used by Saini et al.<sup>7</sup> involved an electronic measure which they internally validated by comparing the measure to a manual review of a select number of charts. It demonstrated high specificity (97%) and low sensitivity (20%). This low sensitivity suggests misclassification of overuse as appropriate. For these reasons, we are confident that the true national rate of overuse is unlikely to be below the results found in this study.

The high interval of the credible range identified by Kruse et al.,<sup>5</sup> 25.7%, is the highest rate of overuse of screening colonoscopy identified by any previously published study. Kruse et al.<sup>5</sup> used an electronic algorithm to identify overuse that had previously been found to identify overuse of screening colonoscopy with a sensitivity of 88% and specificity of 96%. Given the relatively high sensitivity of their electronic algorithm, most cases of overuse that occurred during the study period were likely identified. However, Kruse et al.<sup>5</sup> did not follow a large percentage of patients for a total of 9 years as their median follow-up time was 6.1 years. This suggests the true rate of overuse of screening colonoscopy may be higher than the result found by Kruse et al.<sup>5</sup> Despite these shortcomings, Kruse et al.<sup>5</sup> represent the highest rate of overuse identified by this systematic review.

## DISCUSSION

Screening colonoscopy is recommended as a first-line option for colorectal cancer screening by most national guidelines within the USA.<sup>2,16-18</sup> When adherent to guidelines, screening colonoscopy is thought to reduce colorectal cancer mortality

and incidence, with benefits outweighing harms.<sup>19</sup> However, screening colonoscopy performed more often than recommended by guidelines or in populations older or younger than recommended wastes resources and places patients at risk unnecessarily. This systematic review found that between 17 and 25.7% of screening colonoscopies occurring in the USA are likely overuse.

The annual number of screening colonoscopies performed in the USA was estimated to be 6.3 million in 2012.<sup>20</sup> Given the credible range of inappropriate screening colonoscopies identified by this study, this would translate to at least 1 million unnecessary colonoscopies occurring in the USA annually. This estimate should raise concern, due to both the increased cost to the healthcare system and risks to patient safety in the context of preventable harms [BMJ REF to come to SB]. Major harms associated with colonoscopy include significant bleeding requiring transfusion, GI perforation, and death.<sup>21</sup> Even without serious harm, colonoscopy is likely a burdensome experience for most patients given the discomfort of bowel preparation,<sup>22</sup> the out-of-pocket cost of the procedure and associated sedation, work days lost, and post-procedural pain and recovery.

In addition to the potential harm caused by low-value colonoscopy, the financial costs to the healthcare system are substantial. A recent CDC analysis estimated the average cost of screening colonoscopy in the USA to be \$3,153.<sup>23</sup> Applying the CDC estimate to the credible range identified in this study suggests more than \$3 billion are wasted annually on unnecessary screening colonoscopies.

Like the overuse of many other medical interventions, several diverse factors drive non-indicated screening colonoscopy. These drivers may be patient-based, clinician-based, or system-based. For example, the Veterans Administration (VA) system has been found to have lower rates of unnecessary medical interventions in general.<sup>15</sup> It has been proposed the VA may have lower rates of overuse than the healthcare system as a whole due to flat payments to providers rather than fee for service.<sup>24</sup> Additionally, the insulated nature of the VA system might reduce overuse. Calls for payment models that replace fee for service have been raised specifically for gastroenterology, with one expected benefit being a reduction in unnecessary screening colonoscopies.<sup>25</sup>

Two studies identified by this systematic review found non-indicated early screening colonoscopy was associated with the endoscopist's recommendation, with an odds ratio of 3.8–6.3.<sup>5,6</sup> Inappropriate recommendation for early repeat colonoscopy may be a common cause of overuse; the New York City Colonoscopy Quality Benchmarking Group found that 79.6% of endoscopists incorrectly recommended follow-up after normal colonoscopy, with more than half of endoscopists recommending follow-up sooner than five years.<sup>26</sup> Non-indicated recommendations by clinicians may stem from lack of awareness of the USPSTF and Multi-Society Task Force guidelines.<sup>27</sup>

On the patient side, demand for non-indicated screenings<sup>28</sup> may be an unintended consequence of public health messaging, which often encourages screening without providing balanced information about frequency, age limits, or the potential for harm. Patient-facing education, including improved public health messaging, may reduce inappropriate patient demand.

Given the ongoing COVID-19 pandemic, non-indicated screening colonoscopy raises additional risks for both the patient and the endoscopy staff. A study from Italy found 4.2% of endoscopy staff contracted COVID by March 21, at a time when 0.078% of the country had tested positive (Ourworldindata.org), suggesting endoscopy staff are at heightened risk of COVID infection.<sup>29</sup> The risk of iatrogenic COVID transmission to patients during colonoscopy has not been clearly identified, but the same study from Italy found 1% of patients developed COVID-like symptoms within 15 days of endoscopy.<sup>29</sup> However, large or small the risk of COVID transmission from colonoscopy may be, it is entirely avoidable for non-indicated colonoscopy. For this reason, the ASGE recommended delaying elective screening colonoscopies,<sup>30</sup> a recommendation that has likely had the unintended benefit of reducing overuse. As screening colonoscopy is resumed, special attention should be paid to colonoscopies non-adherent to the guidelines, to avoid the unnecessary risk of COVID transmission in addition to the previously identified risks of colonoscopy.

Indeed, all risks of harm from the overuse of screening colonoscopies are potentially preventable. While there are increasing numbers of reports documenting the rate of overuse, few studies to date have examined the rate of harm it causes. Having that information available for clinicians and patients could help them avoid it.<sup>31</sup> We plan to use the results from this study for a future paper to estimate rates of harm from overuse of screening colonoscopy.

## Limitations

Repeat colonoscopies due to inadequate bowel preparation may have been labeled as overuse leading to an overestimate of overuse. However, studies evaluating repeat colonoscopies occurring less than 6 months after initial colonoscopy were excluded, making it unlikely that repeat colonoscopies were included in the rates of overuse in this analysis. Nearly all of the studies identified in this systematic review emphasized specificity at the cost of sensitivity. This ensures that the rate of overuse identified by the studies is very unlikely to overestimate the true rate of overuse of screening colonoscopy. In addition, the only study which used a more sensitive data collection method, Kruse et al.,<sup>5</sup> did not follow patients long enough after index colonoscopy to identify all cases of overuse. Thus, the credible range offered by this systematic review represents a reliable low estimate, with the true rate of overuse almost certainly above the low estimate provided. The true rate of overuse of screening colonoscopy could also be higher than the high end of the credible range.

## CONCLUSION

Unnecessary screening colonoscopy is common within the USA and occurs in 17 to 25.7% of all screening colonoscopies. This overuse increases the cost of healthcare and inflicts harms on patients unnecessarily. These findings should provide additional motivation for both patients and clinicians to eliminate inappropriate colorectal cancer screening by following national cancer screening guidelines.

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## Declarations:

**Conflict of Interest:** The authors declare that they do not have a conflict of interest.

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