

# The Value of Colonoscopic Colorectal Cancer Screening of Adults Aged 50 to 64 Years

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**C**olorectal cancer (CRC) is a common and lethal cancer. In the United States, for those cancers that affect both genders, it is the third most common cancer and the second most common cause of cancer-related deaths. In 2009, the incidence rate for CRC was 42.5 cases per 100,000 population, and the mortality rate was 15.7 per 100,000 population.<sup>1</sup> Fortunately, many cases of CRC and CRC-related deaths are preventable through screening and early detection activities.

Screening and prevention activities for CRC have evolved over the past 2 decades. The first US guidelines for CRC screening were published in 1989.<sup>2</sup> In 2012, the American College of Physicians published a synthesis of guidance statements from other organizations,<sup>3</sup> and a multi-specialty society task force published a consensus update for surveillance after screening and polypectomy.<sup>4</sup>

The natural history of CRC is that approximately 85% of CRC cases arise from adenomas—benign lesions of the colon—and these adenomas leading to CRC take approximately 10 years to grow and progress to localized CRC.<sup>2</sup> From localized CRC, average progression to regional CRC takes approximately 2 years, and from regional to distant (metastatic) takes an additional 2 years.<sup>5</sup>

Screening for CRC is valuable because detection and removal of adenomas and localized CRC interfere with this natural history, preventing CRC and CRC-related deaths. Several techniques have been recommended for CRC screening. Guaiac or fecal immunochemical testing for occult blood in the stool (FOBT) is based on the fact that CRC and adenomas may bleed, and fecal DNA testing is based on the fact that CRC may shed abnormal genetic material into the stool. Virtual colonoscopy using low-dose computed tomography (CT) is an advanced imaging technique that relies on the distortion of colonic lining by CRC or adenomas. Endoscopic techniques (sigmoidoscopy and colonoscopy) are based on direct observation of the colon for CRC and adenomas. Colonoscopy is the

## ABSTRACT

**Objectives:** The purpose of this study was to determine the value of life-years saved due to colorectal cancer (CRC) screening with colonoscopy for the population aged 50 to 64 years. The cost perspective is that of a private (commercial) insurer, while the value perspective includes survival past age 65 years, when most of the US population is insured by Medicare. We focused on colonoscopy because it is not only diagnostic but also therapeutic; because positive results on other screening tests generally are followed up with colonoscopy; and to build on previous study results that colonoscopy is ultimately more cost-effective than other screening, even considering its expense.

**Study Design:** Monte Carlo simulation.

**Methods:** Using a large multi-state cancer registry, a large national administrative claims database, and a model of CRC development based on published clinical literature, we estimated the impact of screening with colonoscopy on incidence of CRC, aggregate cost of colonoscopies and CRC, and life-years saved.

**Results:** Assuming 2013 commercial reimbursement rates for screening and treatment, we found that increasing screening adherence from 50% to 100% would cost about \$3 per member per month (2013 US\$) and reduce CRC treatment costs by about \$1 per member per month. The cost per life-year saved is approximately \$12,000, an amount that is much lower than for cervical or breast cancer screening and comparable to lung cancer screening.

**Conclusions:** Our results suggest that commercial insurers and employers should promote CRC screening as a high-value service. Promoting such screening through high-quality, low-cost providers would be an exemplar of efficient system innovation.

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only screening and detection technique that examines the entire colon, and simultaneously enables removal of adenomas.

Colonoscopy screening programs have been shown to decrease CRC mortality. The National Polyp Study showed that colonoscopy with removal of adenomatous polyps could prevent subsequent CRC.<sup>6</sup> Long-term follow-up of these patients found a 53% reduction in CRC mortality compared with that expected based on Surveillance Epidemiology and End Results Program (SEER) data for CRC mortality in the general population.<sup>7</sup>

A decision analysis commissioned to inform US Preventive Services Task Force (USPSTF) guidelines used 2 microsimulation models to estimate life-years gained from colonoscopy screening relative to no screening. The decision analysis was from a societal perspective, studied effects over the entire lifetime of individuals, and did not include costs of screening or treatment. This analysis supported CRC screening with colonoscopy every 10 years starting at age 50 years.<sup>8</sup>

The Healthy People 2020 target is that 70.5% of adults aged 50 to 75 years be up-to-date with this recommended cancer screening. As of 2010, the National Health Interview Survey found that 62% reported ever having a colonoscopy or sigmoidoscopy, and 13% reported home-based FOBT in the previous 2 years.<sup>9</sup> Similarly, in 2011, Healthcare Effectiveness Data and Information Set (HEDIS) measures of CRC screening showed that 62.4% of the commercially insured health maintenance organization (HMO) population had been appropriately screened, and 54.6% of the commercial preferred provider organization population had been appropriately screened, based on USPSTF recommendations.<sup>10</sup>

The purpose of this study was to determine the value of life-years saved due to CRC screening with colonoscopy for the population aged 50 to 64 years. Our price perspective is that of a commercial payer (including amounts paid by patients), while our value perspective includes survival past age 65 years, when most of the US population is insured by Medicare. We used recent adjudicated commercial claims data to calculate the cost of CRC screening and cost of patients for the 4 years after CRC diagnosis by stage. We focused on colonoscopy because it is not only diagnostic but also therapeutic; because positive results on other screening tests generally are followed up with colonoscopy; and to build on previous study results that colonoscopy is ultimately more cost-effective than other screening, even considering its expense.<sup>8,11</sup>

### Take-Away Points

Screening commercially insured individuals for colorectal cancer with colonoscopy is a high-value service:

- The study perspective is that of a third-party payer for a working-age population.
- The study uses standard actuarial methodology that payers find understandable and relevant.
- Cost per year of life saved is approximately \$12,000—less than for breast or cervical cancer.
- Costs of colonoscopy and cancer care are up-to-date and inclusive.
- Effects on mortality are estimated past age 65 years.
- Sensitivity analysis demonstrates cost-effectiveness within a wide range of assumptions about costs and benefits.

## STUDY DATA AND METHODS

Our model was designed to estimate the cost and cost-benefit of CRC screening with colonoscopy for US adults aged 50 to 64 years—those among the working-age population for whom CRC screening is recommended. This target population consists of about 23% of the 158 million US individuals who are commercially insured and aged less than 65 years (approximately 36 million people). We applied standard actuarial methods that are often used when evaluating insurance features or coverage. Population details were derived from 2010 and earlier US Census Bureau projections.

### Data Sources and Methods for Cost of Colonoscopy

We used Truven Health MarketScan Research Databases 2010-2011, a large commercial database of paid health benefits claims, to develop the cost of colonoscopy. (See the [eAppendix](#) [available at [www.ajmc.com](http://www.ajmc.com)] for the colonoscopy codes used.) The cost of a screening colonoscopy can include professional fees for both the procedure and anesthesia, as well as facility fees, laboratory/pathology services, and supplies. To capture costs comprehensively, we selected patients aged 50 to 64 years undergoing a colonoscopy and tabulated all costs occurring on the day of the colonoscopy. We did not include any follow-up costs that may have occurred on subsequent days. (See [Table 1](#) for the cost of colonoscopy.)

### Data Sources and Methods for Cost, Incidence, and Mortality of Colorectal Cancer by Stage

We developed the cost of CRC for 3 stages to approximate the SEER categorization into local, regional, and distant, where local is the most curable and distant (metastatic) is the most fatal. We used Truven Health MarketScan Research Databases 2007-2011 to develop CRC costs by stage. Because cancer stage is not directly

**Table 1. Costs Associated With Colonoscopy and Treatment of CRC**

Description	Sample Size <sup>a</sup>	Average Cost Per Patient <sup>b</sup> (\$)
Colonoscopy		
With removal of polyps	124,187	2488
Without removal of polyps	107,034	1858
Local CRC		
0-12 months from diagnosis	1775	50,273
13-24 months from diagnosis	1264	23,808
25-36 months from diagnosis	890	24,869
37-48 months from diagnosis	310	33,440
Regional CRC		
0-12 months from diagnosis	1002	151,276
13-24 months from diagnosis	703	55,652
25-36 months from diagnosis	460	52,640
37-48 months from diagnosis	136	35,255
Distant CRC		
0-12 months from diagnosis	288	193,592
13-24 months from diagnosis	134	155,551
25-36 months from diagnosis	51	134,562
37-48 months from diagnosis <sup>c</sup>	0	134,562

CRC indicates colorectal cancer.

<sup>a</sup>For CRC costs, this represents the sample size at the beginning of the period.

<sup>b</sup>For CRC costs, this represents the annual cost adjusted for mortality.

<sup>c</sup>Insufficient sample size; assumed to have the same average cost as months 25-36.

Source: Authors' analysis of Truven Health MarketScan Research Databases 2007-2011, costs trended to 2013.

identified in standard claims coding, we used treatment surrogates to categorize the stage at diagnosis. (See the eAppendix for the algorithm used.) CRC cases were identified as new if the individual had no claims coded with cancer in the 12 months prior to diagnosis. All costs of new cases by each of the 3 stages were tabulated by month from diagnosis for up to 4 years. Because the database does not distinguish death from other causes of insurance termination, we composited the monthly costs using a survivorship function developed from SEER data. Table 1 shows the cost of CRC by stage and year from index diagnosis date. Mortality by year following diagnosis for each stage was developed by incident age from SEER data. **Table 2** shows the CRC mortality rates.

Mortality rates for people without CRC were obtained from the CDC National Vital Statistics Reports. Costs for people without CRC were developed from Truven Health MarketScan Research Databases data by age and sex.

Shifting the stage of detection from later stages of CRC to earlier stages is one of the values of screening. Underlying the calculation of stage shifting is a model of the natural history of CRC development in the absence of interference. Specifically, we make assumptions that localized CRC

arises from adenomas that, on average, have been present 10 years, and that the time from local to regional CRC is 2 years and from regional to distant CRC is 2 years.<sup>2,5</sup> The time in each stage is referred to as the “sojourn time.”

Because colonoscopic adenoma removal reduces the incidence of CRC by stage, we developed incidence rates with and without colonoscopy by age, sex, and stage. CRC incidence rates by stage from 1975-1977 SEER<sup>12</sup> were assumed to reflect CRC incidence for individuals who had not had colonoscopy, as it was not recommended for screening in those years. Based on the literature, about 15% of CRC does not emerge from adenomas.<sup>2</sup> Incidence rates of cancer not arising from adenoma consisting of 15% of the 1975-1977 SEER incidence rates could be thought of as representing a “theoretical best” incidence outcome of colonoscopy, if colonoscopy could detect and remove all adenomas before cancer developed. However, colonoscopy may miss some CRC cases that are exceptionally fast-growing, or the patient may have inadequate preparation where some adenomas may be missed, so we needed to develop “best practical” incidence rates. SEER CRC incidence from 2007-2009<sup>12</sup> shows much lower rates of regional and distant cancers than 1975-1977 data and

■ **Table 2.** Select Mortality Rates for Patients Diagnosed With CRC

Gender	CRC Stage	Age (years) at Time of Diagnosis	Mortality Rate in Months Following CRC Diagnosis (%)				
			0-12	13-24	25-36	37-48	49-60
Male	Local	50-54	2.0	1.6	1.8	1.9	2.3
		55-59	2.7	2.5	2.5	2.5	2.4
		60-64	3.7	2.6	3.2	3.1	4.2
	Regional	50-54	5.3	7.0	7.7	7.1	6.4
		55-59	6.1	7.7	8.2	8.2	8.6
		60-64	7.6	7.9	8.6	9.7	7.9
	Distant	50-54	36.4	38.9	34.5	30.1	20.2
		55-59	38.5	38.1	37.4	32.8	26.9
		60-64	41.5	39.8	37.8	29.8	27.3
Female	Local	50-54	1.1	1.0	1.6	1.6	1.7
		55-59	1.9	1.5	2.2	2.1	2.4
		60-64	2.9	2.1	2.7	2.5	2.8
	Regional	50-54	3.0	6.1	6.5	7.2	5.2
		55-59	5.0	7.5	7.0	5.8	6.5
		60-64	6.7	8.1	7.9	7.1	6.8
	Distant	50-54	32.9	38.9	33.5	28.6	22.2
		55-59	37.2	37.1	33.3	27.8	20.1
		60-64	43.0	40.3	31.7	30.2	22.2

CRC indicates colorectal cancer.

Source: National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER\*Stat Database: Incidence — SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2011 Sub (1973-2009 varying) – Linked To County Attributes – Total U.S., 1969–2010 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch, released April 2012, based on the November 2011 submission.

reflects widespread, although incomplete, use of screening. We assumed that the 2007-2009 incidence reflects a blend of “best practical” and 1975-1977 incidence rates caused by the impact of about 50% screening. The 50% screening assumption is close to that reported by HEDIS in 2009.<sup>10</sup> **Table 3** shows incidence rates from 1975-1977 SEER,<sup>12</sup> as well as our “best practical” incidence rates.

USPSTF recommendations call for screening colonoscopies every 10 years starting at age 50 years for the normal risk population. For the working-age population, this means screening at ages 50 and 60 years, which is assumed in our model. According to these guidelines, individuals with adenomas should obtain a follow-up screening in 5 years, and we developed the portion of colonoscopies receiving this follow-up based on findings from the literature.<sup>13</sup>

All costs were trended to 2013 levels using a 5% annual trend, which reflects recent commercial unit price increases.<sup>14</sup>

### Simulation Methods

Estimates for the impact of screening on incidence of CRC, aggregate cost of colonoscopies and CRC, and

life-years, were developed through Monte Carlo simulation. Fifteen successive annual cohorts of men and women turning age 50 years starting in 1998 were processed in the model for up to 15 years to produce a typical US population aged 50 to 64 years in 2013. No individuals who reached age 65 years were included in the model. Individuals were randomly assigned to be screened (or not screened) at ages 50 and 60 years. Separate runs of the simulation tested different screening scenarios, ranging from 0% to 100%. Based on adenoma incidence rates identified in the screening colonoscopy claim data analysis, a portion of the individuals screened at age 50 years were randomly assigned to an adenoma group to receive an additional screening at age 55 years following recommendations.<sup>4</sup> Individuals were attributed with CRC (by stage) or no CRC by applying incidence probabilities. The incidence probabilities by stage varied depending on whether the individual had received screening or not.

Annual costs and annual life or death determinations (including for those 65 years and older) were assigned to each individual. The costs for people without cancer var-

■ **Table 3.** Incidence Rates of CRC With and Without Screening

Gender	Age (years)	CRC Incidence Rates per 100,000						Reduction (–) / Increase (+) in Incidence Rates Due to Screening (%)		
		With 0% Screening <sup>a</sup>			With “Best Practical” Screening <sup>b</sup>			Local	Regional	Distant
		Local	Regional	Distant	Local	Regional	Distant			
Male	50-54	17.2	17.8	13.0	24.2	14.7	8.9	40.5	–17.4	–31.7
	55-59	34.2	35.7	22.0	20.2	14.9	9.2	–40.9	–58.3	–58.3
	60-64	55.3	52.3	36.7	35.3	20.9	9.5	–36.1	–60.0	–74.0
Female	50-54	15.6	18.0	10.7	19.9	12.5	7.1	27.7	–30.6	–34.2
	55-59	28.2	31.4	18.8	15.0	11.8	7.5	–46.9	–62.6	–60.2
	60-64	37.3	46.0	27.0	23.7	15.4	7.9	–36.3	–66.6	–71.0

CRC indicates colorectal cancer; SEER, Surveillance, Epidemiology, and End Results.

<sup>a</sup>From SEER 1975-1977 data.

<sup>b</sup>From authors' analysis.

Source: National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER\*Stat Database: Incidence — SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2011 Sub (1973-2009 varying) – Linked To County Attributes – Total U.S., 1969–2010 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch, released April 2012, based on the November 2011 submission.

ied depending on the person's age and sex. For people with cancer, costs varied by stage and years since diagnosis. People without CRC were assigned average costs based on the person's age and sex. People receiving colonoscopy received additional cost in the year of colonoscopy.

Colonoscopies, cancer diagnoses, and non-cancer costs were assumed to occur at the beginning of the year. Mortality was assumed to occur at the end of the year. Future life expectancies were tabulated using mortality rates that varied by age and sex, stage, and duration of CRC.

The model follows individuals for up to 15 years (for the cohort that turned age 50 years in 1998) and reaches a steady state for spending and cancer incidence in 2013. At this steady state, all ages in the 50-to-64-year-old cohort have been subject to the chosen screening scenario. For each scenario, costs and future life expectancy were tabulated for each individual alive in 2013. Under our assumption that cost trends equal discount rates, for any given screening scenario, all spending would remain constant after 2013, as would the number of cancer cases by stage and the population. Consequently, for cost and cost-benefit analysis, we simply tabulated results for 2013. Neither inflation-adjustments nor discounting was applied or necessary.

## RESULTS

### Cost/Benefit Analysis

We present the results of the simulation model in **Table 4**, calibrated to a typical health plan with 100,000 commercial members, which would include 23,000 members aged 50 to 64 years. Compared with no screening, 50% adherence (our baseline) with the recommendations for colonoscopy

(age 50 and 60 years) would cost \$11,562 per life-year saved and result in an additional 4 individuals alive in 2013 who are aged 50 to 64 years. Annual spending for colonoscopies would be \$4.07 million and would yield 252 future life-years saved. Increasing colonoscopies to 70% would increase life-years saved to 348 and would result in 7 more individuals alive than would be the case with no screening. In the screening scenarios, the life-year calculation considers the individuals who are alive and those who will not develop CRC because of screening, as well those whose earlier diagnosis will reduce their mortality.

Sensitivity tests are shown in **Table 4**. Increasing or decreasing cancer costs by 10% produced costs per life-year saved of \$10,758 or \$12,778, respectively. Increasing or decreasing colonoscopy costs by 25% produced costs per life-year saved of \$15,853 or \$7684, respectively. Reduced or improved screening effectiveness produced costs per life-year saved of \$14,816 or \$9583, respectively.

### Colorectal Cancer Screening Versus Other Cancer Screenings

**Table 5** compares the cost per life-year saved of well-established cancer screenings with that of CRC screening. We applied medical inflation adjustments to bring the published figures for cervical, breast, and lung cancer up to the price levels associated with our 2013 estimate for colorectal cancer.<sup>15</sup> This was necessary because prominent studies of the cost effectiveness of cancer screening were conducted more than 10 years ago.

As shown, the cost per life-year saved projected to 2013 dollars was \$50,162 to \$75,181 for cervical cancer, \$31,309 to \$51,274 for breast cancer, and \$19,805 for lung cancer.

■ **Table 4.** Costs and Benefits of CRC Screening With Colonoscopy Under Alternative Sensitivity Scenarios: Commercially Insured Population of 100,000 Members (~23,000 between the ages of 50 and 64 years)

Description	2013 Lives (50-to-64-Year-Olds)	Annual Colonoscopy and CRC Costs (millions \$)				Annual Cost of Care (millions \$)	Life-Years Saved	Cost per Life-Year Saved (\$)
		Colonoscopy	CRC					
			Local	Regional	Distant			
No screening	22,990	0.00 (\$0.00 PMPM)	0.99 (\$0.82 PMPM)	2.35 (\$1.95 PMPM)	1.98 (\$1.65 PMPM)	176.2		
Current screening (~50% Screening)	22,994	4.07 (\$3.39 PMPM)	0.88 (\$0.74 PMPM)	1.74 (\$1.45 PMPM)	1.40 (\$1.16 PMPM)	179.2	252	11,562
Feasible target (70% Screening)	22,997	5.69 (\$4.74 PMPM)	0.85 (\$0.71 PMPM)	1.49 (\$1.24 PMPM)	1.18 (\$0.99 PMPM)	180.3	348	11,768
100% screening	23,000	8.12 (\$6.77 PMPM)	0.79 (\$0.66 PMPM)	1.12 (\$0.93 PMPM)	0.84 (\$0.70 PMPM)	182.1	404	11,798
<b>Alternative scenarios (changes from "feasible target" scenario of 70% screening)</b>								
10% lower cancer costs	22,997	5.69	0.76	1.34	1.06	180.0	348	10,758
10% higher cancer costs	22,997	5.69	0.93	1.64	1.30	180.7	348	12,778
25% lower colonoscopy costs	22,997	4.27	0.85	1.49	1.18	178.9	348	7684
25% higher colonoscopy costs	22,997	7.11	0.85	1.49	1.18	181.8	348	15,853
Reduced screening effectiveness 10%	22,996	5.69	0.91	1.59	1.28	180.6	292	14,816
Increased screening effectiveness 10%	22,998	5.69	0.80	1.36	1.09	180.1	404	9583
<small>CRC indicates colorectal cancer; PMPM, per member per month. Results shown for members aged 50 to 64 years. Source: Authors' simulation analysis.</small>								

In the baseline scenario, the 2013 estimate for the cost per life-year saved was \$11,768 for colorectal cancer.

## DISCUSSION

We used actuarial techniques to study the value to commercial payers of screening and prevention of CRC using colonoscopy. We found that the cost per life-year saved, assuming that 70% of the population was screened, was \$11,768, which is comparable to our estimate for cost per life-year saved for lung cancer screening with low-dose CT scanning.<sup>16,17</sup>

We applied sensitivity testing to our model for several inputs. We found that cost per life-year saved, if the costs of colonoscopy were 25% lower than our baseline scenario, would be \$7684, while it would be \$15,853 if the costs of colonoscopy were 25% higher. We also found that cost per life-year saved, if the cost of cancer care varied by 10%

either way from baseline, would be \$10,758 to \$12,778. Additionally, changing the effectiveness of screening yielded estimates of cost per life-year saved of \$9583 to \$14,816.

Previous studies of cost-effectiveness of colorectal screening have also found that screening for CRC is cost-effective compared with no screening. The cost-effectiveness of CRC screening has improved over time, with newer studies showing cost per life-year gained ranging from \$19,000 to actually being cost-saving, while older studies have suggested a range of \$13,000 to \$32,000 cost per life-year gained.<sup>18</sup>

In older studies, the choice of optimal testing strategy was very sensitive to variation in the costs of the screening tests. In 2009 dollars, the costs for colonoscopy in US studies ranged from \$460 to \$1570. Four studies using Medicare costs used \$533 as the cost of colonoscopy<sup>18</sup>; a study from 2000 that analyzed a mixed commer-

■ **Table 5.** Cost of Cervical, Breast, Lung and Colorectal Cancer Screening Per Life-Year Saved

Type of Cancer	Screening Technique	Year of Original Report	Cost Per Life-Year Saved in Original Report (\$)	Cost Per Life-Year Saved Trended to 2013 (\$)
Cervical <sup>22</sup>	Pap	2000	33,000	52,670-78,940
Breast <sup>23,24</sup>	Mammography	1997	18,800	32,874-53,838
Lung <sup>16</sup>	Low dose CT	2012	18,862	19,805
Colorectal <sup>a</sup>	Colonoscopy	2013	11,768	11,768

<sup>a</sup>For colorectal cancer, the source was the authors' analysis of Truven Health MarketScan Research Databases 2007-2011, with costs trended to 2013.

cial/Medicare population used a blended rate derived from Truven Health MarketScan Research Databases and Medicare 5% sample claim data and described the range as \$779 to \$1192.<sup>19</sup> Another study from 2000 chose \$1570, based on information from a regional HMO.<sup>20</sup> The incremental cost of polypectomy in US studies ranged from \$162 to \$480 for Medicare-derived cost,<sup>18</sup> and from \$442 to \$786 for costs in the regional HMO.<sup>20</sup> Some studies included the costs of treatment of the most common serious complication of colonoscopy—perforation—and those estimates ranged from \$342 to \$50,193; some models did not include perforation. Cost of care for CRC was also variable across studies, with some assuming that cost did not vary by stage; others input actual costs from HMO or Medicare, depending on state of disease and type of care.<sup>21</sup>

Our approach to costs was to use actual costs of medical care based on a database of claims paid by commercial health insurers in 2011. We captured all costs on the day of the screening colonoscopy, not simply the professional component of the procedure. Likewise, we based the costs of treatment of CRC diagnosed at the various SEER stages (local, regional, distant) on actual claims data. Furthermore, we placed the costs of CRC prevention, screening, and treatment in the context of the total spending by commercial health insurers. We did not consider the societal impact of life-years saved, such as productivity, taxes, or benefits. We did tabulate life-years saved beyond age 65, but we did not consider that screening the population aged 65 years or less will reduce the burden of CRC on the federal Medicare program.

### Limitations

Our methodology and model have several limitations. No single source provided all necessary data, so we relied on multiple sources that may be confounding. For example, we applied sojourn times between CRC stages from the literature, but the studies were not based solely on people aged 50 to 64 years. Additionally, for the

cost of CRC treatment, we assigned CRC stage based on treatment. Because some patients may not receive guideline-concordant treatment, this may lead to some level of stage misclassification.

We used SEER data for incidence and mortality estimates by age and sex, and these data include individuals who may not have commercial insurance. Any differences in population incidence and mortality for CRC by source of healthcare funding would not be accounted for.

While statistics on the risk reduction of many interventions exist from randomized controlled trials, no such figures are available for the stage shift or incidence reduction associated with full adherence to the colonoscopy regimen. The “best practice” incidence rates we developed were based on mathematical processes applied to the historical changes in CRC incidence rates, which we associated with the implementation of CRC screening.

For ease of modeling, we considered only colonoscopies, but other modalities are also recommended, including screening for fecal occult blood, visualization with sigmoidoscopy, or virtual colonoscopy with low-dose CT. We assumed the current reported CRC adherence rate of about 50%, which is defined to include screening modalities other than colonoscopy and a fairly loose definition of adherence. It is likely that truly effective screening is lower than 50%, which could mean the opportunity for reducing incidence and stage shifting is larger than we report. We note that the ability of colonoscopy to both reduce incidence of CRC and to detect CRC earlier means our results could be seen as showing somewhat greater impact than if other methods were used.

Our findings are based on a model that has reached a “steady state,” which has advantages in transparency in that it avoids the need for inflationary or present value (discounting) adjustments. It is also relatively clear for its application to payers; however, it has disadvantages in that it tabulates only future life-years saved (including life-years after age 65 years), not life-years saved in the past. It also does not consider the past investment needed to

produce the “steady-state” results, only the ongoing costs. This is, in effect, a “snapshot analysis” that parallels typical health plan annual fiscal reporting.

Our scenarios assume that screened individuals obtain colonoscopies at ages 50 and 60 years. Of course, in reality, people do not always get screened on schedule. We made no explicit allowance for the many variations that can occur that could reduce colonoscopy effectiveness, such as inadequate bowel preparation, polyps that were missed by the colonoscopist, or complications from colonoscopy. Some of these variations are implicitly captured by our model’s calibration to the 2007-2009 incidence rates and the assumption that those rates reflect about 50% adherence to recommended CRC screening.

Some individuals with adenomas are diagnosed with villous type where the recommendation for additional screening is 3 years versus the 5-year recommendation for nonvillous type. Because the incidence of villous adenoma is not reported by age in the literature, we assumed a 5-year surveillance screening colonoscopy for every adenoma detected at the age 50 years colonoscopy screening. This could cause our CRC screening costs to be somewhat underestimated. However, along with 3-year screening there would likely be reduced CRC costs with earlier detection of colon cancer. The cost per life-year saved (\$11,768; again, assuming 70% of the population was screened), is lower than most estimates of cost per life-year saved for breast and cervical cancer.<sup>22-24</sup>

## CONCLUSIONS

CRC is a disease associated with substantial medical and economic burden, and it is in large part preventable or diagnosable at a localized stage with screening colonoscopy and resection of adenomas. In our investigation of CRC screening for the US population aged 50 to 64 years, using actual screening and treatment costs, we found that both the cost of screening and the cost per life-year saved compare favorably with published rates for other cancer screenings. Under the Affordable Care Act (ACA), preventive services including colonoscopy are considered essential health benefits for fully insured groups, including group and individual products offered on or off the health-care exchanges, and require no patient cost sharing. While some of the self-insured population covered under Administrative Services Only plans may not be subject to the same ACA requirements and obligations as fully insured groups, employers utilizing these arrangements should note the overall relative value of screening and consider the enhanced benefits of encouraging colorectal cancer

screening among employees. In this context, commercial insurers, as well as employers, should continue to consider CRC screening with colonoscopy to be of substantial value.

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## REFERENCES

1. US Cancer Statistics Working Group. United States Cancer Statistics: 1999-2009 Incidence and Mortality Web-based Report. Atlanta, GA: CDC and National Cancer Institute; 2013.
2. Winawer SJ, Fletcher RH, Miller L, et al. Colorectal cancer screening: clinical guidelines and rationale. *Gastroenterology*. 1997;112(2):594-642.
3. Qaseem A, Denberg TD, Hopkins RH, Jr, et al; Clinical Guidelines Committee of the American College of Physicians. Screening for colorectal cancer: a guidance statement from the American College of Physicians [published correction appears in *Ann Intern Med*. 2012;157(2):152]. *Ann Intern Med*. 2012;156(5):378-386.
4. Lieberman DA, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR; United States Multi-Society Task Force on Colorectal Cancer. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology*. 2012;143(3):844-857.
5. Loeve F, Brown ML, Boer R, van Ballegoijen M, van Oortmarssen GJ, Habbema JD. Endoscopic colorectal cancer screening: a cost-saving analysis. *J Natl Cancer Inst*. 2000;92(7):557-563.
6. Delcò F, Sonnenberg A. At what age should a one-time only colonoscopy for screening of colorectal cancer be performed? *Eur J Gastroenterol Hepatol*. 1999;11(11):1319-1320.
7. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *N Engl J Med*. 2012;366(8):687-696.
8. Zauber AG, Lansdorp-Vogelaar I, Knudsen AB, Wilschut J, van Ballegoijen M, Kuntz KM. Evaluating test strategies for colorectal cancer screening: a decision analysis for the U.S. Preventive Services Task Force. *Ann Intern Med*. 2008;149(9):659-669.
9. Cancer trends progress report. National Cancer Institute website. <http://progressreport.cancer.gov>. 2011/2012 update. 2012 update accessed April 1, 2013
10. The state of health care quality 2012. Washington, DC: National Committee for Quality Assurance; 2012:1-228.
11. Sonnenberg A, Delcò F, Bauerfeind P. Is virtual colonoscopy a cost-effective option to screen for colorectal cancer? *Am J Gastroenterol*. 1999;94(8):2268-2274.

12. National Cancer Institute. Surveillance, Epidemiology, and End Results (SEER) Program SEER\*Stat Database: Incidence — SEER 18 Regs Research Data + Hurricane Katrina Impacted Louisiana Cases, Nov 2011 Sub (1973-2009 varying) — Linked To County Attributes — Total U.S., 1969–2010 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, Surveillance Systems Branch, released April 2012, based on the November 2011 submission. [www.seer.cancer.gov](http://www.seer.cancer.gov). Accessed April 1, 2013.
13. Corley DA, Jensen CD, Marks AR, et al. Variation of adenoma prevalence by age, sex, race, and colon location in a large population: implications for screening and quality programs. *Clin Gastroenterol Hepatol*. 2013;11(2):172-180.
14. Health care costs: a primer. Kaiser Family Foundation website. [kff.org/health-costs/report/health-care-costs-a-primer/](http://kff.org/health-costs/report/health-care-costs-a-primer/). Published May 1, 2012. Accessed April 1, 2013.
15. Consumer Price Index: frequently asked questions. US Bureau of Labor Statistics website. <http://www.bls.gov/cpi/cpifaq.htm>. Updated September 17, 2014. Accessed October 1, 2014.
16. Pyenson BS, Sander MS, Jiang Y, Kahn H, Mulshine JL. An actuarial analysis shows that offering lung cancer screening as an insurance benefit would save lives at relatively low cost. *Health Aff (Millwood)*. 2012;31(4):770-779.
17. Maciosek MV, Coffield AB, Flottesch TJ, Edwards NM, Solberg LI. Greater use of preventive services in U.S. health care could save lives at little or no cost. *Health Aff (Millwood)*. 2010;29(9):1656-1660.
18. Lansdorp-Vogelaar I, Knudsen AB, Brenner H. Cost-effectiveness of colorectal cancer screening. *Epidemiol Rev*. 2011;33:88-100.
19. Khandker RK, Dulski JD, Kilpatrick JB, Ellis RP, Mitchell JB, Baine WB. A decision model and cost-effectiveness analysis of colorectal cancer screening and surveillance guidelines for average-risk adults. *Int J Technol Assess Health Care*. 2000;16(3):799-810.
20. Frazier AL, Colditz GA, Fuchs CS, Kuntz KM. Cost-effectiveness of screening for colorectal cancer in the general population. *JAMA*. 2000;284(15):1954-1961.
21. Pignone M, Saha S, Hoerger T, Mandelblatt J. Cost-effectiveness analyses of colorectal cancer screening: a systematic review for the U.S. Preventive Services Task Force. *Ann Intern Med*. 2002;137(2):96-104.
22. Kim JJ, Wright TC, Goldie SJ. Cost-effectiveness of alternative triage strategies for atypical squamous cells of undetermined significance. *JAMA*. 2002;287(18):2382-2390.
23. Ahern CH, Shen Y. Cost-effectiveness analysis of mammography and clinical breast examination strategies: a comparison with current guidelines. *Cancer Epidemiol Biomarkers Prev*. 2009;18(3):718-725.
24. Rosenquist CJ, Lindfors KK. Screening mammography beginning at age 40 years: a reappraisal of cost-effectiveness. *Cancer*. 1998;82(11):2235-2240. ■

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## eAppendix

### Colonoscopy claim identification logic

Data source: Truven MarketScan data 2010-2011.

Eligibility criteria:

- Aged 50 to 64 years.
- No colorectal cancer (CRC) screening history or CRC diagnosis in 12 months prior to index colonoscopy date.
- Must have 12 months' eligibility prior to index colonoscopy date.

Colonoscopy with polyps, tumors or other cancer was identified as:

CPT Code	Code Description	Diagnosis Code
45380	Colonoscopy with biopsy	Any
45383	Colonoscopy with ablation of lesions	Any
45384	Colonoscopy with lesion removal by hot biopsy forceps or bipolar cautery	Any
45385	Colonoscopy with lesion removal by snare technique	Any
45378	Diagnostic colonoscopy	211.3 <sup>a</sup>
G0105	Colorectal cancer screen; high risk indicated	211.3 <sup>a</sup>
G0121	Colorectal cancer screen; high risk not indicated	211.3 <sup>a</sup>

<sup>a</sup>*International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnosis code 211.3 described as “Benign neoplasm of other parts of digestive system, Colon.”

Colonoscopy without polyps, tumors or other cancer was identified as:

CPT Code	Code Description	Diagnosis Code
45378	Diagnostic colonoscopy	Any, other than 211.3 <sup>a</sup>
G0105	Colorectal cancer screen; high risk indicated	Any, other than 211.3 <sup>a</sup>
G0121	Colorectal cancer screen; high risk not indicated	Any, other than 211.3 <sup>a</sup>

<sup>a</sup>*ICD-9-CM* diagnosis code 211.3 described as “Benign neoplasm of other parts of digestive system, Colon.”

We identified all other costs occurring on the same date of service as the colonoscopy, and included these costs in the total colonoscopy cost estimates.

## CRC stage claim identification logic

Data source: Truven MarketScan data 2007-2011.

Eligibility criteria:

Aged 50 to 64 years: must be aged at least 50 in index year and aged no more than 64 during the 24 or 36 months after index CRC diagnosis.

Must have 12 months eligibility prior to index CRC diagnosis and eligibility for at least 1 month after CRC index diagnosis

**Step 1:** Identify all CRC patients in 2008 and 2009 (we will follow claim cost for 36 months after diagnosis of CRC patients at each stage and annualize costs; 2009 index cases will only contribute to 24 months after diagnosis costs):

At least 2 claims for colon (*ICD-9-CM* code 153.xx) or rectal cancer (*ICD-9-CM* codes 154.0x, 154.1x, 154.8x), at least 15 days apart during the index year, in any position on a medical claim; first claim will be considered index CRC diagnosis date.

**Step 2:** Exclude cases with claims coded with CRC in the 12 months prior to CRC index date.

**Step 3:** Determine stage of cancer for these “newly diagnosed” CRC patients.

Distant CRC: At least 2 claims for metastases (*ICD-9-CM* codes 196.0x-196.1x, 196.3x-196.5x, 196.8x, 197.0x-197.3x, 197.7x, 198.xx), the first claim occurring within 30 days of CRC index date and the second within 60 days of first metastasis claim in any position on the medical claim record.

**Regional CRC.** Does not meet Distant CRC criteria AND has 1 or more claims coded with the following chemotherapy or radiation therapy codes within 6 months of CRC index date AND has an inpatient claim for CRC surgery within 12 months of CRC index date:

### Chemotherapy HCPCS Codes

bevacizumab	J9035
cetuximab	J9055
5-fluorouracil	J9190
leucovorin	J0640
irinotecan	J9206
capecitabine	J8520, J8521
oxaliplatin	J9263
panitumumab	J9303
aflibercept	C9291
levoleucovorin	J0641

HCPCS indicates Healthcare Common Procedure Coding System.

National Drug Code codes for capecitabine (oral chemotherapy):

0004-1100-20
0004-1100-75
0004-1101-50
0004-1101-51
0004-1101-75
53808-0411-1
54868-4143-0
54868-4143-1
54868-4143-2
54868-4143-3
54868-5260-0
54868-5260-1
54868-5260-2
54868-5260-3
54868-5260-5
54868-5260-9

Radiation Therapy Current Procedural Terminology-4 codes:

77427	Radiation treatment management and treatment
77431	Radiation treatment management with complete course of therapy
77401	Radiation treatment delivery
77402	Radiation treatment delivery
77403	Radiation treatment delivery
77404	Radiation treatment delivery
77406	Radiation treatment delivery
77407	Radiation treatment delivery
77408	Radiation treatment delivery
77409	Radiation treatment delivery
77411	Radiation treatment delivery
77412	Radiation treatment delivery
77413	Radiation treatment delivery
77414	Radiation treatment delivery
77416	Radiation treatment delivery
77418	Radiation treatment delivery, imrt
77421	Stereoscopic x-ray guidance
77750	Infuse radioactive materials
77761	Apply intracavitary radiation source, simple
77762	Apply intracavitary radiation source, intermediate
77763	Apply intracavitary radiation source, complex
77776	Apply interstitial radiation source, simple
77777	Apply interstitial radiation source, intermediate
77778	Apply interstitial radiation source, complex
77785	High dose rate radionuclide brachytherapy, 1 channel
77786	High dose rate radionuclide brachytherapy, 2-12 channels
77787	High dose rate radionuclide brachytherapy, over 12 channels
77789	Apply surface radiation
77790	Radiation handling
77799	Radium/radioisotope therapy

Radiation Oncology revenue codes:	
0333	Radiology - Therapeutic - Radiation Therapy

**Local Colorectal Cancer (CRC):** Does not meet Regional or Distant CRC criteria AND does not have claims for regional list of chemotherapy drugs or claims coded with Regional list of radiation oncology codes. Local CRC patients in this cohort can have claims for chemotherapy not in the Regional cohort chemotherapy list.