Cost-Savings to Medicare From Pre-Medicare Colorectal Cancer Screening

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Background: Many individuals have not received recommended colorectal cancer (CRC) screening before they become Medicare eligible at the age of 65. We aimed to estimate the long-term implications of increased CRC screening in the pre-Medicare population (50–64 y) on costs in the pre-Medicare and Medicare populations (65+ y).

Methods: We used 2 independently developed microsimulation models [Microsimulation Screening Analysis Colon (MISCAN) and Simulation Model of CRC (SimCRC)] to project CRC screening and treatment costs under 2 scenarios, starting in 2010: "current trends" (60% of the population up-to-date with screening recommendations) and "enhanced participation" (70% up-to-date). The population was scaled to the projected US population for each year between 2010 and 2060. Costs per year were derived by age group (50–64 and 65+ y).

Results: By 2060, the discounted cumulative total costs in the pre-Medicare population were $35.7 and $28.1 billion higher with enhanced screening participation, than in the current trends scenario ($252.1 billion with MISCAN and $239.5 billion with SimCRC, respectively). Because of CRC treatment savings with enhanced participation, cumulative costs in the Medicare population were $18.3 and $32.7 billion lower (current trends: $423.5 billion with MISCAN and $372.8 billion with SimCRC). Over the 50-year time horizon an estimated 60% (MISCAN) and 89% (SimCRC) of the increased screening costs could be offset by savings in Medicare CRC treatment costs.

Conclusion: Increased CRC screening participation in the pre-Medicare population could reduce CRC incidence and mortality, whereas the additional screening costs can be largely offset by long-term Medicare treatment savings.

Key Words: colorectal cancer, screening, computer simulation, prevention and control

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Approximately 130,000 individuals were newly diagnosed with colorectal cancer (CRC) in the United States (US) in 2010.[1] Regular screening for CRC and its precursor lesions, adenomas, can prevent the disease or detect it at an earlier stage when treatment is potentially more effective. Current guidelines recommend screening for CRC beginning at age 50.[2–5] Although the proportion of individuals participating in screening is increasing, only 58% of the 50- to 75-year-old population is up-to-date with screening according to guidelines.[6]

In the US, many individuals have not received recommended CRC screening when they become Medicare eligible at age 65. Some may initiate screening after becoming Medicare eligible, and others may never undergo a screening examination. In either case, Medicare will have to reimburse for the treatment of CRC that might have been prevented if screening had been done at an earlier age. Because CRC screening requires an investment in the short term with savings expected to accrue in the longer term, there may be financial incentive for public programs to support efforts to enhance screening participation before individuals turn 65. Over the past decade an increasing number of local, state, and federal screening programs have been established to increase CRC screening participation.[7–9]

We aimed to estimate the long-term implications of enhanced CRC screening participation in the pre-Medicare population (50–64 y) on the distribution of costs related to

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TABLE 1. Screening Participation Among Individuals Aged 50 Years and Older in the Current Trends and Enhanced Participation Scenarios

	Current Trends (%)		Enhanced Participation (%)	
	2010	2015–2060	2010	2015–2060
Proportion of population				
Up-to-date with screening*	58	60	58	70
Ever screened in lifetime	64	65	64	75
Proportion of screening participants currently screened with				
FOBT	13	13	13	13
Endoscopy	87	87	87	87
Proportion of last endoscopies that were colonoscopies†	93	96	100	100
Adherence to diagnostic colonoscopy after positive FOBT or sigmoidoscopy	80	80	90	90
Adherence to surveillance colonoscopy	80	80	90	90

*Up-to-date with screening is defined as having had an FOBT within the past year, sigmoidoscopy in the past 5 years, or a colonoscopy within the past 10 years.
†Endoscopy was either colonoscopy or sigmoidoscopy.
FOBT indicates fecal occult blood test.

CRC screening and treatment in the pre-Medicare and Medicare (aged 65 y and older) populations.

METHODS

We used 2 independently developed microsimulation models, Microsimulation Screening Analysis Colon (MISCAN-Colon) and Simulation Model of CRC (SimCRC), to compare the annual and cumulative costs of CRC screening and treatment under current trends in screening participation (60% of the population up-to-date with screening) and under a scenario with enhanced screening participation among the pre-Medicare population (70% up-to-date). Using 2 models (ie, a comparative modeling approach) serves as a sensitivity analysis on the underlying structural assumptions of the models, particularly pertaining to the natural history of CRC.

Microsimulation Models

Both MISCAN and SimCRC are part of the Cancer Intervention and Surveillance Modeling Network (CISNET), a consortium funded by the National Cancer Institute. Detailed model descriptions are provided in Appendix 1 (Supplemental Digital Content 1, http://links.lww.com/MLR/A957), in standardized

TABLE 2. Unit Costs of CRC Screening and Treatment, in 2010 US Dollars, in the Pre-Medicare and Medicare Populations

Screening Costs (Per Procedure)	Pre-Medicare Population ($)*				Medicare Population ($)			
FOBT (Hemoccult II and Hemoccult Sensa)	6				5			
FIT (only used in sensitivity analysis)	30				23			
Stool DNA (only used in sensitivity analysis)†	629				493			
Sigmoidoscopy without biopsy	270				211			
Sigmoidoscopy with biopsy	300				235			
Colonoscopy without polypectomy	876				687			
Colonoscopy with polypectomy	905				710			
Diagnostic test outside program	870				682			
Treatment of complications from‡								
Colonoscopy	7301				5722			
Sigmoidoscopy	16,702				13,089			
CRC Treatment Costs (Per Person, Per Year of Care)§	**Stage I**	**Stage II**	**Stage III**	**Stage IV**	**Stage I**	**Stage II**	**Stage III**	**Stage IV**
Initial phase	33,332	46,330	56,678	74,278	26,122	36,309	44,418	58,212
Continuing phase	2721	2537	3626	11,239	2132	1988	2841	8808
Terminal phase, death CRC	61,312	61,138	64,421	86,458	48,050	47,914	50,486	67,757
Terminal phase, death other causes	15,106	13,213	17,480	46,934	11,839	10,355	13,699	36,782

*In the pre-Medicare population, the reimbursement rate was assumed to be 128% of the Medicare reimbursement; 74%, 6%, and 8% of the pre-Medicare population were insured by private insurance, Medicaid, and Medicare, respectively, and 12% was uninsured.[30] The reimbursement rate for these payers relative to Medicare was 140%, 100%, 90%, and 90%, respectively (uninsured individuals were assumed to get Medicaid care).[31]
†Source for Medicare reimbursement rate of the stool DNA test.[32]
‡Rate of serious nonfatal complications was assumed to be 2.4 per 1000 colonoscopies and 0.2 per 10,000 sigmoidoscopies.[33–35] Rate of fatal events was assumed to be 1 per 10.000 colonoscopies.[36]
§Costs of care were divided into 3 phases of care: initial, continuing, and terminal care. The initial phase of care was defined as the first 12 months following diagnosis. The terminal phase of care was defined as the final 12 months of life, and the continuing phase was defined as all months between the initial and terminal phases. The terminal care phase was further subdivided into terminal care preceding CRC death and terminal care preceding death from other causes. For patients who survived <24 months after diagnosis, the final 12 months were allocated to the terminal phase because the care for patients with short survival is more similar to the terminal phase than to the initial phase after diagnosis. The remainder of survival time was allocated to the initial phase. The lifetime costs of CRC care per patient result from multiplying the cost per phase of care by the number of life years lived in each phase (eg, a Medicare beneficiary diagnosed with stage III CRC and surviving 1 year in initial, 1 year in continuous, and 1 year in terminal care before dying of CRC incurs $76,304 ($26,122+$2132+$48,050) for his CRC treatments.
CRC indicates colorectal cancer; FIT, fecal immunochemical test; FOBT, fecal occult blood test.

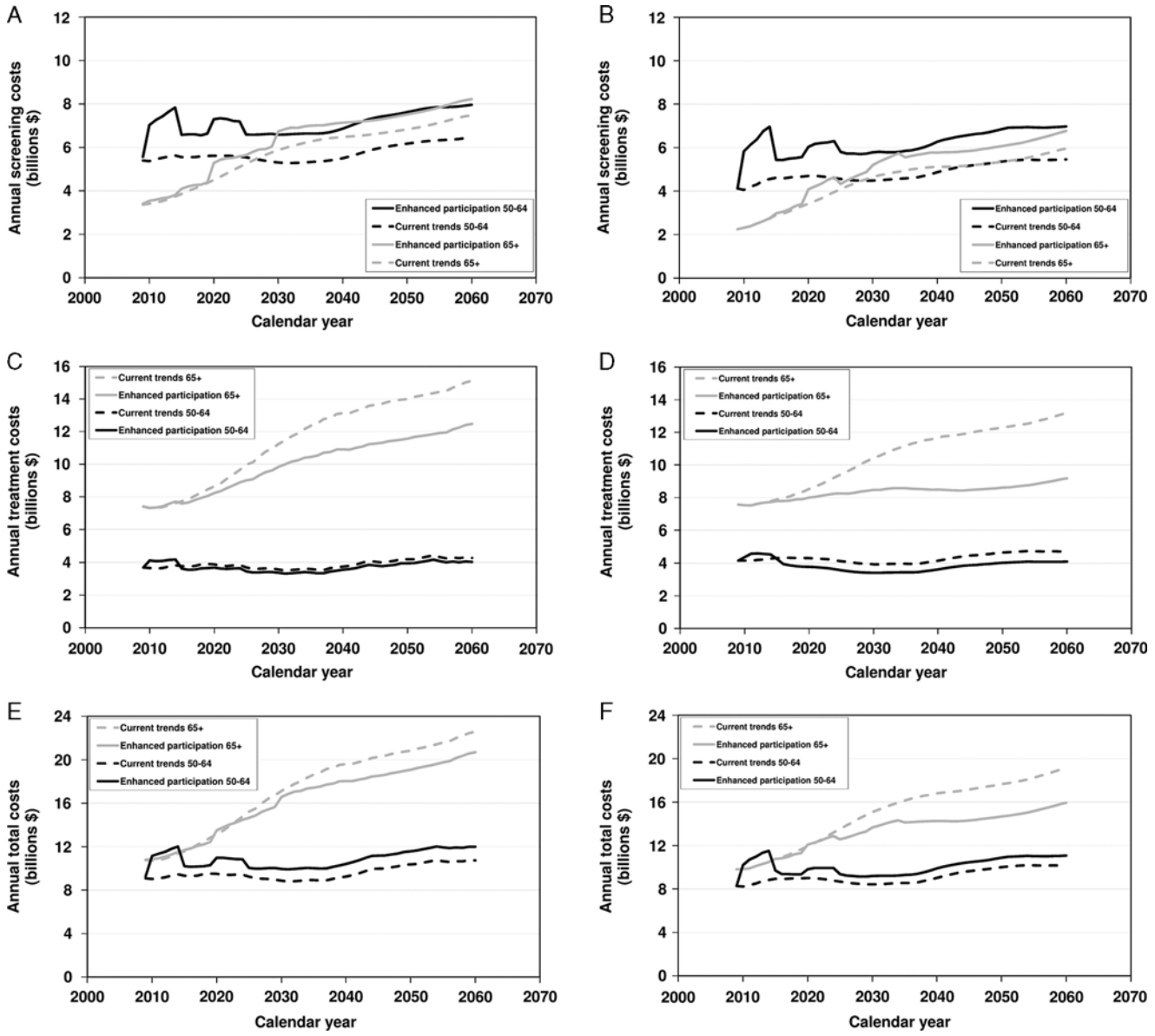


FIGURE 1. Annual CRC screening, treatment, and total costs in the current trends and enhanced participation scenarios, in the US population of 50 years and older. A, Annual CRC screening costs (MISCAN)*. B, Annual CRC screening costs (SimCRC)*. C, Annual CRC treatment costs (MISCAN)†.D, Annual CRC treatment costs (SimCRC)†. E, Annual total CRC-related costs (MISCAN). F, Annual total CRC-related costs (SimCRC). The black curves represent costs incurred in the pre-Medicare population (50–64 y) and the gray curves represent costs incurred in the Medicare population (65+ y). All costs are undiscounted and are expressed in 2010 US dollars. *The peaks in the annual screening costs in the enhanced participation scenario are the effect of increased colonoscopy screening in the population aged 50–64 at the start of the scenario (screening participation is increased over 5 y), and their subsequent screening around 10 years later. Annual screening costs remain higher after that, because of new 50-year-old individuals taking up screening each year. †The increasing trend in screening and treatment costs in the Medicare population (and to a lesser extent also in the pre-Medicare population) in the current trends scenario, reflects the increasing proportion of the population reaching old age. CRC indicates colorectal cancer.

model profiles available online[10] and in previous publications.[11–14] In brief, both models simulate the life histories of individuals from birth to death. CRC arises in the population according to the adenoma-carcinoma sequence.[15,16] More than one adenoma can occur in an individual and each adenoma can independently develop into CRC. Adenomas can progress in size from small ($\leq$5 mm) to medium (6–9 mm) to large ($\geq$10 mm), and some may eventually become malignant. A preclinical cancer has a chance of progressing through stages I to IV and may be detected by symptoms at any stage. After clinical diagnosis of CRC, survival depends on the stage at diagnosis. At any time during his/her life an individual may die of other causes.

TABLE 3. Cumulative CRC Screening, Treatment, and Total Costs (Billions of 2010 US Dollars) at Ten Year Intervals in the Current Trends and Enhanced Participation Scenarios (3% Discounted)

	MISCAN ($)						SimCRC ($)					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Current trends scenario												
Pre-Medicare population (50–64 y)												
Screening	5.4	52.8	87.7	113.0	133.8	150.3	4.1	42.7	71.6	93.5	111.6	125.8
Treatment	3.7	35.9	59.4	76.4	90.5	101.8	4.2	40.6	66.8	85.7	101.3	113.7
Total	9.0	88.7	147.1	189.4	224.3	252.1	8.2	83.3	138.4	179.1	212.9	239.5
Medicare population (65+ y)												
Screening	3.4	36.8	70.2	99.7	123.1	141.8	2.3	26.9	52.9	76.2	94.5	109.2
Treatment	7.3	74.2	137.5	195.8	243.7	281.7	7.5	75.2	135.4	188.2	230.3	263.6
Total	10.7	110.9	207.7	295.6	366.7	423.5	9.8	102.0	188.3	264.4	324.8	372.8
Total population (50+ y)												
Screening	8.8	89.6	157.9	212.7	256.8	292.1	6.4	69.5	124.5	169.7	206.1	235.0
Treatment	11.0	110.0	196.9	272.2	334.2	383.5	11.7	115.8	202.2	273.8	331.7	377.2
Total	19.8	199.6	354.9	485.0	591.0	675.6	18.1	185.3	326.7	443.5	537.7	612.2
Difference between enhanced screening and current trends scenario												
Pre-Medicare population (50–64 y)												
Screening (A)	1.7	14.5	23.3	29.5	34.5	38.5	1.8	14.3	23.1	29.2	34.2	38.2
Treatment	0.5	1.0	−0.3	−1.3	−2.1	−2.7	0.2	−0.4	−3.9	−6.4	−8.4	−10.1
Total	2.1	15.5	23.0	28.2	32.5	35.7	2.0	13.9	19.2	22.9	25.8	28.1
Medicare population (65+ y)												
Screening (B)	0.1	1.7	4.9	8.4	10.7	12.6	0.0	0.9	4.0	7.2	9.6	11.6
Treatment (C)	0.0	−1.1	−7.1	−15.9	−24.2	−30.9	0.0	−1.5	−9.4	−21.9	−34.2	−44.3
Total	0.1	0.5	−2.1	−7.5	−13.5	−18.3	0.0	−0.6	−5.4	−14.7	−24.6	−32.7
Total population (50+ y)												
Screening	1.8	16.1	28.2	37.9	45.2	51.0	1.8	15.2	27.1	36.4	43.8	49.7
Treatment	0.5	−0.1	−7.4	−17.2	−26.3	−33.6	0.2	−1.9	−13.3	−28.3	−42.7	−54.4
Total	2.3	16.0	20.8	20.7	18.9	17.4	2.0	13.3	13.8	8.2	1.2	−4.6
Offset (C/(A+B)) (%)*	—	7	25	42	54	60	—	10	35	60	78	89

*The percent of increased screening costs in the pre-Medicare and Medicare populations offset by Medicare treatment savings.
CRC indicates colorectal cancer; MISCAN, Microsimulation Screening Analysis Colon; SimCRC, Simulation Model of CRC.

The adenoma prevalence by age predicted by the models was calibrated to adenoma prevalence data from autopsy studies.[17–25] The adenoma prevalence in unscreened individuals aged 65 was 39.8% and 37.1% in MISCAN and SimCRC, respectively. The clinical CRC incidence by age and stage at diagnosis predicted by the models in the absence of screening was calibrated to data from the Surveillance, Epidemiology, and End-Results (SEER) program from 1975 to 1979, which represented an era before the introduction of screening.[26] The lifetime CRC incidence in unscreened, cancer-free individuals aged 65 was 5.8% and 5.7% in MISCAN and SimCRC, respectively. The relative survival after diagnosis of CRC by age and CRC stage was based on SEER data from individuals diagnosed in the period 2000–2003.

To ensure that differences in model results were due mainly to differences in the natural history component of the models, most inputs were standardized across the 2 models, including test characteristics (Appendix 1d, Supplemental Digital Content 1, http://links.lww.com/MLR/A957), screening, and follow-up assumptions and costs. In addition, we used a sample size of at least 600 million individuals, and used the same seeds for the random number generators in each run, to minimize the impact of stochastic noise on the model outcomes.

Study Population

We simulated births between 1910 and 2010, resulting in a population aged 0–100 years in 2010, and 50–100 years in 2060. The size and age composition of the population will change due to fluctuations in number of births and in life expectancy over time. To account for the combined effect of these population dynamics, for each year between 2010 and 2060 we scaled the number of individuals by age to the US census bureau population projections for that same period.[27] This resulted in approximately 40.2 million individuals aged 65 and older in 2010, increasing to 92.0 million in 2060.

Base-Case Analysis

The screening history before 2010 was based on 1987–2010 National Health Interview Survey data.[28] We assumed individuals would be screened with fecal occult blood test (FOBT), sigmoidoscopy, or colonoscopy. The overall screening participation increased over time to the point where in 2010, 64% of the population aged 50 and older had ever had a screening, and 58% of the population was up-to-date with screening according to guidelines.[2–5] From 2010 onward we modeled 2 screening scenarios: "current trends" and "enhanced participation" (Table 1). In the current trends scenario, screening participation was assumed to level off at 65% ever screened and 60% up-to-date with screening by 2015.

In the enhanced participation scenario we assumed that the screening participation would increase to a level comparable to current mammography screening.[29] The screening participation was increased linearly between 2010 and 2015, to a point

where 75% of the population ever had a screening, and 70% would be up-to-date with screening. Enhanced screening participation was applied to individuals aged 50–64 years. Individuals over age 65 in 2010, already enrolled in Medicare, would not change their screening behavior. However, individuals who changed their screening behavior before age 65 would continue their new behavior as they age.

We assumed that screening in the enhanced participation scenario would be done with either FOBT or colonoscopy. Individuals previously screened with sigmoidoscopy would switch to colonoscopy from 2010 onwards. The proportion of individuals receiving FOBT and colonoscopy were assumed equal to the proportions observed in the 2010 National Health Interview Survey (13% FOBT and 87% colonoscopy)[28] and were assumed to remain constant over time. Because the more sensitive Hemoccult Sensa is recommended over Hemoccult II,[2–5] we assumed that all individuals screened with FOBT as a result of the enhanced participation would receive Hemoccult Sensa.

Follow-up and Surveillance

Adenomas can be detected and removed during diagnostic colonoscopy after a positive FOBT or sigmoidoscopy, or during primary colonoscopy screening. Depending on the number and size of adenomas detected, individuals would be recommended surveillance colonoscopy after 5 or 10 years, according to current guidelines.[2–5] The adherence to diagnostic and surveillance colonoscopy was assumed to remain constant over time; 80% in the current trends scenario, and 90% under enhanced participation.

Expenditures

The analysis was conducted from a health care system perspective and included only direct medical costs. The models capture the costs associated with screening and follow-up of positive screening tests (screening costs), and CRC-specific care by stage at diagnosis (treatment costs, Table 2). The costs for screening procedures in the Medicare population were based on Medicare payments in 2007.[36] In addition, the cost of negative screening colonoscopies were increased to reflect the removal of cost sharing for many patients as a result of the Affordable Care Act (ACA).[37]

CRC treatment costs per person, per year of care in the Medicare population were derived from a comparison of medical costs for CRC patients relative to Medicare beneficiaries without a CRC diagnosis matched by sex, age, and SEER registry area in the 1998–2003 SEER-Medicare data.[38] The costs vary by CRC stage at diagnosis and phase of care. The lifetime costs of CRC care per patient result from multiplying the cost per phase of care by the number of years lived in each phase. For example, a Medicare beneficiary diagnosed with stage III CRC and surviving 1 year in initial, 1 year in continuous, and 1 year in terminal care before dying of CRC incurs a total of $76,304 ($26,122+$2132+$48,050) for his CRC treatments.

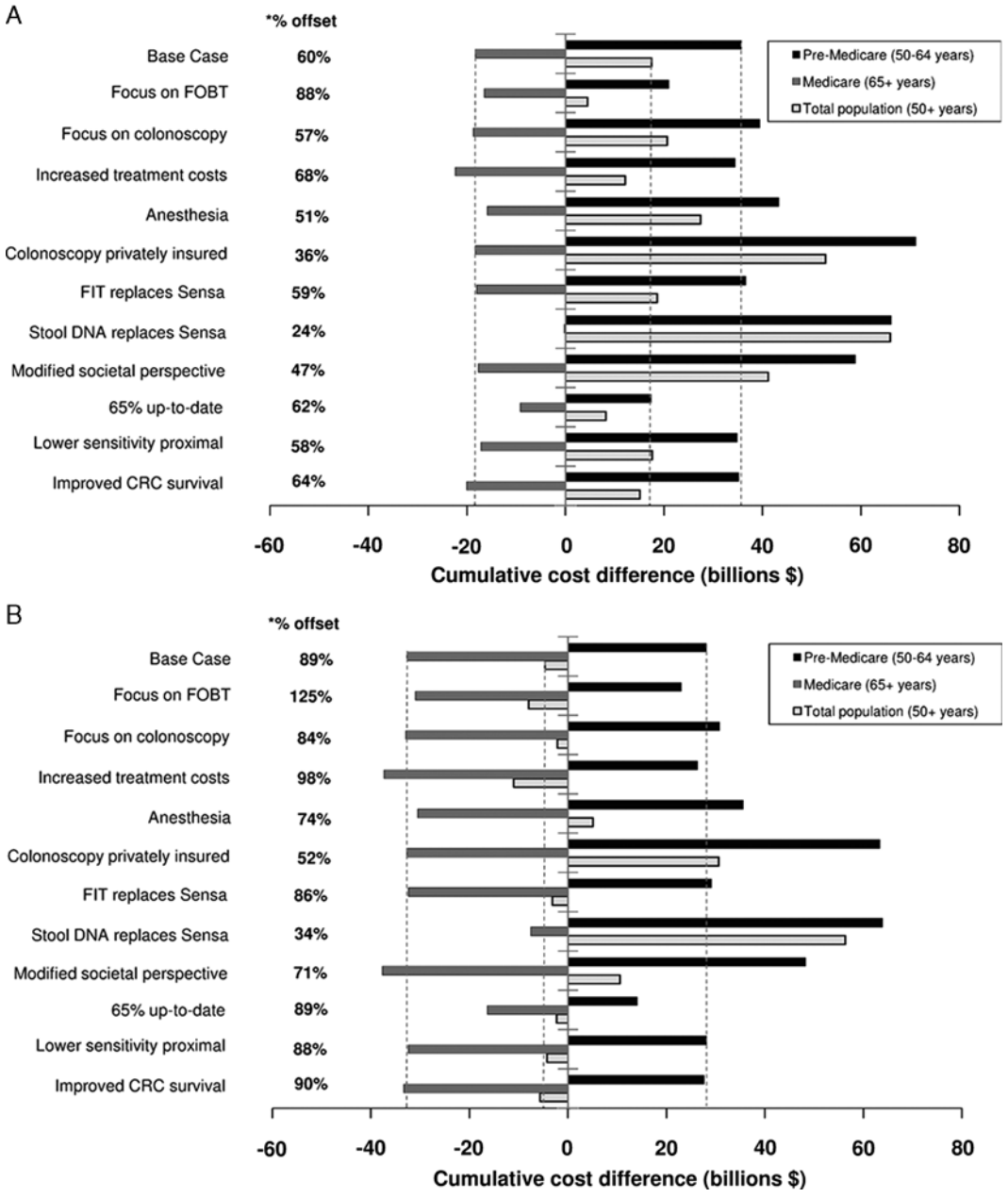
FIGURE 2. Results of sensitivity analyses. Cumulative cost difference (billions of 2010 US dollars, 3% discounted) of the enhanced participation scenario, compared with current trends by the year 2060. A, Outcomes for MISCAN. B, Outcomes for SimCRC. Base-case: under enhanced participation the proportion of individuals up-to-date with screening is increased to 70%, compared with 60% under current trends. In both scenarios 87% of screening participants receive colonoscopy and 13% receive FOBT screening. Focus on FOBT: all individuals changing their screening behavior in the enhanced participation scenario would be screened with Hemoccult Sensa. Individuals who were screened with Hemoccult II or endoscopy in the current trends scenario and did not change their screening behavior, would continue to receive Hemoccult II and endoscopy screening respectively. Focus on colonoscopy: all individuals changing their screening behavior in the enhanced participation scenario would be screened with colonoscopy. Individuals who were screened with Hemoccult II in the current trends scenario and did not change their screening behavior, would continue to receive Hemoccult II screening. Increased treatment costs: treatment costs for terminal care in all stages and initial care in stage IV CRC were increased by 30% to reflect the increasing proportion of patients receiving surgery and adjuvant chemotherapy and the increasing costs of these therapies.[42,43] Colonoscopy with anesthesia: costs of colonoscopy procedures were increased by $152 (with polypectomy) and $135 (without polypectomy) to reflect use of monitored anesthesia.†Colonoscopy privately insured: colonoscopy costs in the privately insured pre-Medicare population were increased to 3 times the Medicare reimbursement rate to reflect the higher reimbursement rate for privately insured individuals. FIT replaces Sensa: all individuals screened with Hemoccult Sensa in the base-case received FIT instead. The Medicare reimbursement rate for FIT was assumed to be $23, compared with $5 for Hemoccult Sensa. Stool DNA replaces Sensa: all individuals changing their screening behavior in the enhanced participation scenario would be screened with the Cologuard multitarget stool DNA test. Individuals who were screened with Hemoccult II or endoscopy in the current trends scenario and did not change their screening behavior, would continue to receive Hemoccult II and endoscopy screening, respectively. The screening interval with stool DNA was 3 years and the assumed Medicare reimbursement rate was $493.[31] Modified societal perspective: next to direct medical costs, patient time costs and beneficiary copayments were included in the analysis. An overview of cost inputs is provided in Appendix Table 2.2, Supplemental Digital Content 1, http://links.lww.com/MLR/A957. 65% Up-to-date with screening: 65% of individuals were up-to-date with screening and 72.5% were ever screened in the enhanced participation scenario, compared with 70% and 75%, respectively, in the base-case. Lower sensitivity proximal lesions: the sensitivity of colonoscopy for proximal lesions was decreased to 65%, 77%, and 92% for small, medium, and large adenomas and CRC,[44] compared with 75%, 85%, and 95% for distal lesions (same as base-case values for entire colon and rectum). Improved CRC survival: CRC relative survival by age and stage at diagnosis was increased by 25% for all individuals. *The percent of increased screening costs in the pre-Medicare and Medicare populations offset by Medicare treatment savings. †On the basis of written personal communication with J. V. Brill, MD, AGAF, Predictive Health LLC, Paradise Valley, AZ. 2011 estimates. CRC indicates colorectal cancer; FIT, fecal immunochemical test; FOBT, fecal occult blood test.

The unit costs for screening procedures and CRC treatments in the pre-Medicare population were assumed to be 28% higher than in the Medicare population to reflect the difference in reimbursement rates between different payers; 74%, 6%, and 8% of the pre-Medicare population were insured by private insurance, Medicaid, and Medicare, respectively, and 12% was uninsured.[39] The reimbursement rate for these payers relative to Medicare was 140%, 100%, 90%, and 90%, respectively (uninsured individuals were assumed to get Medicaid care).[30]

All cost data were inflation adjusted to 2010 US dollars by using the Consumer Price Index[40] and were assumed to remain constant over time.

Outcomes

The main outcomes in this study were undiscounted annual costs and discounted cumulative costs for CRC screening and treatment in the US population from the year 2010 to 2060. The costs were divided into costs incurred in the pre-Medicare population (age 50–64) and Medicare population (age 65 and older). The costs in the enhanced participation scenario were compared with the costs in the current trends scenario. The proportion of public screening investments offset by treatment savings, under the enhanced participation scenario, was calculated as the cumulative treatment savings in the Medicare population divided by the cumulative investment in screening costs in both the younger



and older populations. All cumulative outcomes were discounted by 3% per year.[41]

Sensitivity Analyses

We performed a number of sensitivity analyses to evaluate the impact of parameter uncertainty on the model outcomes. We considered variations in screening behavior, cost inputs, and test characteristics. In addition, we performed an analysis with a modified societal perspective, in which patient time costs were included. A detailed description of the assumptions in the sensitivity analyses is presented in Appendix 2 (Supplemental Digital Content 1, http://links.lww.com/MLR/A957).

RESULTS

For the 50- to 64-year-old population in the current trends scenario, annual CRC screening costs increased from $5.4 billion in 2010 to $6.5 billion in 2060 (MISCAN; Fig. 1A); similar results were found with SimCRC ($4.1 billion in 2010 to $5.5 billion in 2060; Fig. 1B). Introducing a scenario of enhanced CRC screening participation for the pre-Medicare population, beginning in 2010, resulted in approximately $1.5 billion higher annual screening costs in 2060 in this population compared with current trends in both models. The effect of enhanced screening participation on treatment costs in the pre-Medicare population was relatively modest (Figs. 1C, D); by the year 2060 annual treatment costs in the enhanced participation scenario were $0.2 billion lower compared with current trends (range reflects the use of 2 models).

For the Medicare population aged 65 and older in the current trends scenario, annual CRC screening costs increased from $2.3–$3.4 billion in 2010 to $6.0–$7.5 billion in 2060 (Figs. 1A, B). Enhanced screening participation resulted in $0.7–$0.8 billion higher annual screening costs in 2060. Annual CRC treatment costs in the current trends scenario increased from $7.4–$7.6 billion in 2010 to $13.2–$15.1 billion in 2060 (Figs. 1C, D). Enhanced screening participation had a significant impact on treatment costs in the Medicare population; annual treatment costs in 2060 were $2.7–$4.0 billion lower in the enhanced participation scenario compared with current trends. The lower annual treatment costs offset the increased screening costs in the Medicare population 12–14 years after the introduction of enhanced screening participation (Figs. 1E, F).

When considering discounted cumulative costs over the 50-year time horizon, the total costs in the pre-Medicare population was $35.7 billion, or 14.2% ($35.7/$252.1), higher in the enhanced participation scenario compared with current trends with MISCAN (Table 3, see Appendix 3, Supplemental Digital Content 1, http://links.lww.com/MLR/A957 and 4, Supplemental Digital Content 1, http://links.lww.com/MLR/A957 for undiscounted results and intermediate outcomes). With SimCRC, the total pre-Medicare costs were $28.1 billion, or 11.7% ($28.1/$239.5), higher in the enhanced participation scenario compared with current trends. Alternatively, in the Medicare population, the cumulative total costs in the enhanced participation scenario compared with current trends were $18.3 billion, or 4.3% ($18.3/$423.5), lower with MISCAN and $32.7 billion, or 8.8% ($32.7/$372.8), lower with SimCRC. Overall, the proportion of pre-Medicare and Medicare screening costs that were offset by Medicare treatment savings increased from 7%–10% after 10 years, to 25%–35% after 20 years, to 60%–89% after 50 years (Table 3, bottom row).

Sensitivity Analyses

The cumulative cost difference of enhanced participation compared with current trends was robust to most alternative assumptions considered (Fig. 2, see Appendix 2, Supplemental Digital Content 1, http://links.lww.com/MLR/A957 for more detailed outcomes). However, when we assumed that all individuals changing their screening behavior in the enhanced participation scenario would be screened with the Cologuard multitarget stool DNA (with a 3-y interval and Medicare reimbursement rate of $493) the proportion of cumulative screening costs offset by Medicare treatment savings after 50 years decreased from 60% (base-case) to 24% with MISCAN, and from 89% to 34% with SimCRC.

In addition, the assumption that reimbursement rates for colonoscopy procedures in privately insured individuals were 3 times higher than the Medicare reimbursement rate, had no impact on expenditures in the Medicare population, but did decrease the proportion of cumulative screening costs offset by Medicare treatment savings from 60% (base-case) to 36% with MISCAN, and from 89% to 52% with SimCRC.

DISCUSSION

Using 2 independently developed microsimulation models we demonstrated the potential medical cost impact of enhancing screening participation among the pre-Medicare population. Although increased screening participation from 60% to 70% required a net investment in the pre-Medicare population, total costs in the Medicare population decreased, due to savings in treatment costs. According to MISCAN and SimCRC, over a 50-year time horizon the cumulative Medicare treatment savings were estimated to offset, respectively, 60% and 89% of the increased screening costs.

Two studies previously investigated the extent to which investments in pre-Medicare screening could be offset by treatment savings in the Medicare population.[45,46] Ladabaum et al[45] found relatively fewer savings compared with our analysis, whereas Dobson et al[46] found all screening costs to be offset by treatment savings before individuals reach the age of 75. Our study design differs from those 2 studies in that we take into account expected changes in the national population size and age distribution over time. The Ladabaum study considered a population with a fixed population size and age distribution, and the Dobson study considered a subgroup of the population (only those aged 50–64 y at 1 point in time) that was followed through time. In addition, our analysis accounted for the removal of patient cost sharing for screening endoscopies for many patients resulting from the ACA, and for relative differences in reimbursement rates between Medicare and privately insured individuals. Our study design differs to provide a better depiction of the projected impact from increasing screening in the pre-Medicare population on costs across payers on a national

level. The Dobson study has not been peer-reviewed, but it is available in a summary format online.[46] It was presented to a Congressional committee on CRC awareness,[47] signifying the relevance of the issue to health policy.

In 2012, the Health Resources and Services Administration began requiring community health centers to track and report CRC screening rates in the Uniform Data System.[48] This system might play an important role in identifying areas where screening is particularly underused, and help prioritizing targeted interventions. Federal, state, and local public health programs can support public health and health systems partnership to implement evidence-based interventions recommended by The Community Preventive Services Task Force, promote strategies to increase and improve the quality of CRC screening, and support the adoption of organized CRC screening systems.

Despite the randomized controlled trial data that we used for quantification of our models, there is still remaining uncertainty about the natural history of CRC and how it interacts with screening. Using 2 independently developed models, but with common inputs (ie, a comparative modeling approach), serves as a sensitivity analysis on the underlying structural assumptions of the models which cannot be directly obtained from the literature. Both models have been calibrated to CRC incidence rates from a prescreening era (1975–1979), and both models have been extensively validated against clinical trial data on Hemoccult II screening. The main difference between the 2 models that explains the differences in results is the average time it takes for an adenoma to develop into clinically detectable CRC (the adenoma dwell time). If for example, a small adenoma is missed during a screening colonoscopy, a longer dwell time provides more time for that adenoma to be detected at a subsequent colonoscopy, before it progresses into CRC, and thereby preventing the costs associated with CRC treatment. Because SimCRC assumes a longer dwell time than MISCAN, the same number of additional screening procedures results in more treatment savings in SimCRC relative to MISCAN. Overall, the differences in natural history assumptions between the models result in a 29%-point (89%–60%) difference in the overall proportion of pre-Medicare screening investments that is estimated to be offset by treatment savings in the Medicare population.

This study has 4 limitations of note. Firstly, there are no randomized controlled data available yet regarding the effect on incidence and mortality from colonoscopy screening in the general population. However, there are data available for sigmoidoscopy.[49] We assumed the sensitivity of sigmoidoscopy in the distal colon could be extrapolated to the proximal colon when using colonoscopy. Although the sensitivity analysis with reduced sensitivity for proximal lesions demonstrated limited impact of reduced sensitivity, there are studies which suggest the effectiveness of colonoscopy in the proximal colon is lower compared with the distal colon and rectum,[50] which might be caused by differences in progression rate or genetic characteristics of proximal cancers. If the incidence and mortality reduction from colonoscopy is lower for proximal lesions, we would have overestimated the amount of treatment savings resulting from increasing colonoscopy screening. Secondly, we did not account for potential future changes in screening recommendations. Because of advances in technology and increasing scientific knowledge, it is likely that screening recommendations pertaining to the type of screening test used, recommended screening schedule and/or specific recommendations for different subgroups in a population would change within our time horizon. We used a long time horizon, because it takes years for screening to have an effect on treatment savings. However, because of the inability to predict future developments in screening policies we assumed no changes in policy over time. Thirdly, we did not perform a probabilistic sensitivity analysis. To provide stable outcomes over time and for different age groups, we needed runs with a large sample size (at least 600 million individuals). Given the time required to simulate this many individuals in each run, and the large number of draws that need to be performed in a probabilistic sensitivity analysis, such an analysis would require a huge computational effort. In addition, data on the probability distributions of most of the parameter values are lacking, which makes the interpretation of a probabilistic sensitivity analysis difficult and the outcome of limited added value. The most uncertain assumptions of the models pertain to the natural history of CRC, and we evaluated their impact by using 2 independently developed simulation models. Finally, our current trends scenario did not take into account that uptake and adherence with CRC screening guidelines may increase over time due to the enactment of the ACA that abolished cost sharing for preventive services like CRC screening for many patients. However, the results of our analysis of the impact of enhanced participation could shed light on the anticipated effects of this act on future CRC costs; irrespective of which payer bears the costs of screening, the majority of treatment savings will occur later in life, mainly after individuals have reached Medicare eligibility.

In conclusion, increasing screening participation in the pre-Medicare population could reduce CRC incidence and mortality, whereas an estimated 60%–89% of the increased screening costs can be offset by long-term savings in Medicare CRC treatment costs.

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