Nudging to Increase Colorectal Cancer Screening Rates: A Cost-Benefit Analysis of a Medicare Mailed Fecal Immunochemical Test Program

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ABSTRACT

This paper presents a cost-benefit analysis of the implementation of a mailed fecal immunochemical test (FIT) program for Medicare beneficiaries who have fallen behind on recommended colorectal cancer (CRC) screening. An ex-ante cost-benefit analysis was conducted to determine the total net benefits to US society of the implementation of a Medicare Mailed FIT program on one-year and 10-year timelines. Costs and benefits associated with the implementation of such a program were valued using Centers for Medicare and Medicaid Services (CMS) reimbursement rates and results from existing research. Analysis procedures followed Health and Human Services Guidelines for Regulatory Impact Analysis to the maximum extent possible. The base-case net benefits after program year one were estimated to be $9.6 billion with estimated 10-year net benefits of $74.5 billion. Best-case sensitivity analysis outcomes were estimated to be $22.7 billion in net benefits at the end of year one and $202.3 billion in net benefits on a 10-year timeline, while worst-case sensitivity analysis outcomes were estimated to be $1.4 billion in net benefits at the end of year one and $12.5 billion in net benefits on a 10-year timeline. Further sensitivity analyses all yielded positive net benefits on one and 10-year timelines indicating that the implementation of a mailed FIT program for Medicare beneficiaries who have fallen behind on CRC screening offers considerable net benefit to US society.

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INTRODUCTION

Despite being preventable with screening and highly treatable when detected early, over 50,000 Americans die from colorectal cancer (CRC) each year making it the second leading cause of cancer mortality in the United States (Siegel et al. 2020, 145-147). The burden of CRC is not felt equally by all groups throughout the United States and disparities in colorectal cancer incidence, mortality, and screening rates have been well documented across racial and ethnic groups (Jackson et al. 2016, S38-S39), socioeconomic status (Carethers and Doubeni 2020, 355-356), and rural/urban status (Carmichael et al. 2020, 989). Just 67 percent of screening-eligible adults with Medicare only or dual Medicare/Medicaid insurance coverage are up to date on CRC screening (American Cancer Society 2020, 23), but a wide-scale program that utilizes behavioral nudges to increase access to CRC screening tests could help to increase screening rates for Medicare beneficiaries and could also help reduce existing CRC disparities (Doubeni et al. 2022).

This cost-benefit analysis (CBA) evaluates the impact of a program to mail at-home colorectal cancer screening kits to average-risk, screening-eligible Medicare beneficiaries who are not up to date with CRC screening. As a program of this nature has not been proposed or implemented within the Centers for Medicare and Medicaid Services (CMS), this evaluation is an ex-ante analysis of the costs and benefits associated with the development and implementation of such a program. Results are reported as expected net benefits at the end of program year one as well as expected net benefits over a 10-year timeframe.

BACKGROUND

There are several tools currently available for CRC screening. Colonoscopies have long been the gold standard for CRC screening and are the preferred screening method for a majority of healthcare providers. While accuracy has been found to be the most important aspect for most patients when choosing a screening method, many patients take discomfort and preparation into consideration when selecting a test (Ling et al. 2001, 826-827; Xu et al. 2015, 6-7). Fecal immunochemical tests (FIT) and multi-target stool DNA (MT-sDNA) tests offer less invasive at-home screening options; however, when a positive result is found a follow up colonoscopy is still required for diagnostic resolution (US Preventive Services Task Force. 2021).

The Affordable Care Act requires Medicare to cover preventive services based on recommendations from the US Preventive Services Task Force (USPSTF). Based on the USPSTF Colorectal Cancer Screening Recommendations, Medicare covers a range of screening options for those at average risk of CRC. These CRC screening options include a colonoscopy every 10 years, an at-home multi-target stool DNA test every three years, or a FIT once every 12 months. Average risk individuals as defined by the USPSTF are those aged 45-75 without a personal or family history of CRC (US Preventive Services Task Force 2021, 1967-1969). Under the status quo, CRC screening is opt-in and Medicare beneficiaries must visit with a general practitioner to be sent a FIT or MT-sDNA test or must visit a gastro-intestinal specialist to complete a colonoscopy.

The strategy of mailing at-home CRC screening tests is used at the national level in many countries to varying levels of success (Klabunde et al. 2015, 123-125). The theoretical foundations for these programs lie in the field of behavioral economics, with a growing base of evidence demonstrating how changing default options can be used to positively influence public health and health policy (Matjasko et al. 2016, S15-S16; Patel et al. 2020, 39; Purnell et al. 2018, 3). One such concept from the field of behavioral economic that offers insight is Libertarian Paternalism, or Nudge Theory, which refers to the method of influencing decisions without coercion. These nudges offer neither added incentive nor punishment

for program participation, but rather help guide individuals towards the decision they would have made if they were fully informed (Thaler and Sunstein 2008, 5-6). There is a wide breadth of literature that supports the use of nudges to increase cancer screening rates (Matjasko et al. 2016, S17; Patel et al. 2020, 40; Purnell et al. 2018, 4; Barnes et al. 2016, 1567-1569). A program that automatically provides an at-home CRC screening test to those Medicare beneficiaries who are not up to date on their screening may counter some of the irrational behaviors that humans exhibit in the face of uncertainty and guide more individuals towards the best outcome.

Over the last decade, several studies have been carried out within the United States that demonstrate that this method of sending at-home CRC screening tests to eligible individuals can significantly increase screening rates (Brenner et al. 2018, 3351; Coronado et al. 2020, 544-547; Kemper et al. 2018, 4125-4127; Singal et al. 2016, 12-15). There is also evidence that mailing at-home CRC screening tests can even reduce racial disparities in CRC screening rates, particularly among Black Americans (Doubeni et al. 2022) who have the highest incidence of CRC of any racial group in the United States (Augustus and Ellis 2018, 291-292). A particularly notable pilot study by Issaka et al. (2020, 4-5) sent FITs to eligible Medicare Advantage enrollees who were not up to date with screening and found a 29 percent FIT completion rate among this previously unscreened population.

Based on these successful pilot studies, the proposed screening program will identify average-risk Medicare beneficiaries who are not up to date with CRC screening and send them an at-home testing kit. The eligible population would be any beneficiary who has not filed a claim for CRC screening beyond the coverage window (10 years for a colonoscopy, three years for MT-sDNA, one year for FIT). For this analysis, this mailed at-home test program will be compared to the status quo opt-in Medicare CRC screening standard as previously described.

COSTS, BENEFITS AND ASSUMPTIONS

Due to the uncertainty involved with an ex-ante analysis, the calculation of the costs and benefits of the proposed screening program relies on several evidence-based assumptions about expected CRC incidence and mortality rates as well as expected uptake rate of the program. This analysis also relies heavily on costs derived from pilot studies that occurred in specific regions in the US. While program delivery costs may well vary by region in a program delivered at the national level, this analysis relied on the assumption that program costs remain constant across regions and that the costs derived from these regional pilot studies are nationally representative. Table 1 provides a complete display of all costs, benefits, and assumptions that were included in the calculation of this cost-benefit analysis with sources.

ASSUMPTIONS

Progression from precancerous lesions to actual CRC is normally a slow process, taking up to 10 years (Mármol et al. 2017, 3). This slow progression allows for cancer prevention with adherence to screening protocols. Because CRC is considered preventable with screening, this CBA assumes that the individuals who participate in the program can prevent precancerous polyps from developing into CRC, thus avoiding risk of cancer diagnosis and mortality.

TARGET POPULATION

September 2021 data from the Centers for Medicare and Medicaid Services (CMS) report 63,859,805 total Medicare beneficiaries. According to the American Cancer Society

Table 1: Costs, Benefits, and Assumptions

Costs:	Amount (2021 Dollars)	Source
Annual Cost of FIT Test	$16	CMS reimbursement rates
Cost of MT-sDNA	$509	CMS reimbursement rates
Intervention Development Cost Per Patient	$15	Kemper et al. (2018)
Intervention Admin Costs Per Patient	$5	Kemper et al. (2018)
Interventaion Delivery Cost Per Patient	$21	Kemper et al. (2018)
Colonoscopy copayment following positive FIT	$142	Medicare.gov
Physician Reimbusement (per patient)	$257	Medicare.gov
Benefits		
1-year Cost of CRC Treatment on Medicare	$47,653	Luo et al. (2009)
Patient Time Costs of Colorectal Cancer	$6,801	Yabroff et al. (2005)
Value of Statistical Life Central	$15,113,051	HHS Guidelines
VSL High	$23,075,841	HHS Guidelines
VSL Low	$7,150,261	HHS Guidelines
Assumptions:		**Source**
Medicare Enrollees 2021	63,859,805	CMS
Percent of Medicare Enrollees Not Up to Date on CRC Screening	33%	American Cancer Society (2020)
Expected FIT Positive Rate	8.3%	Alsayid et al. (2018)
Screening Uptake Rate	29%	Issaka et al. (2020)
Annual CRC Incidence Rate	37 Cases per 100,000	CDC 2018 cancer statistics
Annual CRC Mortality Rate	13 per 100,000	CDC 2018 cancer statistics

Source: Figure prepared by the author

(2020, 23), 33 percent of Medicare or dual Medicare & Medicaid beneficiaries are not up to date on their CRC screening. This rate was applied to the total Medicare enrollment figures to calculate the number of Medicare enrollees who are not up to date with their CRC screening. By these calculations an estimated 21,073,735 Medicare beneficiaries are not currently up to date with their CRC screening. This figure serves as the target population for the proposed intervention.

EXPECTED CRC INCIDENCE AND MORTALITY

According to the Centers for Disease Control WONDER database, in 2018 the one-year national incidence rate of CRC was 37 cases per 100,000, and the death rate was 13 per 100,000 deaths (Centers for Disease Control and Prevention, 2021). It is assumed that these diagnoses and deaths are mutually exclusive. These rates were applied to the target Medicare population figures to obtain expected values for incidence and mortality rates within this population in the absence of a screening intervention. The resulting figures were an expected CRC incidence of 7,797 and mortality of 2,739 in the target population for this CBA.

FIT POSITIVITY AND PROGRAM UPTAKE

To calculate the costs to CMS for additional follow-up colonoscopies after a positive FIT, an expected FIT positivity rate was required. Based on results from a retrospective cohort study of over 20,000 patients by Alsayid et al. (2018, 1595), an expected FIT positivity rate of 8.3 percent was applied to the expected screening uptake population. A final assumption required to calculate expected program benefit was an expected screening uptake rate for the target population following program intervention. As a baseline rate for cost-benefit calculations, the uptake rate from the pilot study by Issaka et al. (2020, 2) was applied to the target population. Outcomes from this study were selected as the

baseline uptake rate for the proposed study due to the closeness of the intervention design and target population to the proposed program under evaluation in this CBA.

CALCULATIONS OF COSTS AND BENEFITS

Because the nature of this proposal directly impacts CMS, a subset of the Department of Health and Human Services (HHS), this analysis followed HHS Guidelines for Regulatory Impact Analysis (2016) to the maximum extent possible in the calculation of the costs and benefits. In order to calculate the total costs and benefits, all dollar amounts were converted into 2021 dollars using the US Department of Labor Consumer Price Index inflation calculator. Following HHS guidelines which draw from OMB Circular A-4, discount rates of both three percent and seven percent for high and low estimates were applied in sensitivity analyses (A1-A5).

CALCULATION OF COSTS

PROGRAM COSTS

To estimate the costs associated with program development and implementation, reported costs from a study by Kemper et al. (2018, 4127) were converted to 2021 dollars and used in this cost-benefit analysis. In the study, Kemper et al. thoroughly documented the costs associated with a mailed FIT program in Washington state (4125-4127). Their intervention included development of wordless instructions to explain FIT testing procedures, and an introduction letter followed by the mailing of the FIT kit to those not up to date with their screening. Unreturned kits were followed with two automated reminder calls and a reminder letter (4123-4124). The authors reported labor and non-labor costs associated with intervention development, administrative and program management, as well as the actual intervention implementation cost. Management and implementation costs included costs to identify and track eligible patients, send initial mailings, FIT kits, and follow-up reminders (4127). After conversion to 2021 dollars, the intervention development costs were $15.08 per patient, the administrative and program management costs were $4.71 per patient, and the intervention delivery costs were $20.76 per patient. It must be acknowledged that these costs are likely overvalued in this CBA as economies of scale would imply that development of a program for millions of beneficiaries in the Medicare program will likely cost less per patient than development of a smaller program like the one run by Kemper et al. (2018).

COST OF TESTS

The previously discussed program costs did not include the cost of the actual FIT and these costs were assessed based on 2021 CMS reimbursement rates. The annual cost of a FIT test was assessed at $15.92 based on 2021 reimbursement rates. In sensitivity analysis, a multi-target stool DNA test was used for comparison. To stay up to date on screening, these tests only need to be taken once every three years as opposed to the annual FIT, so the CMS reimbursement rate for the multi-target stool DNA was divided by three to come up with an annual cost of $169.62.

FOLLOW-UP COLONOSCOPY COSTS

Quantifying the costs associated with each colonoscopy following a positive FIT is a complex issue. CMS colonoscopy reimbursement rates can be easily obtained through the medicare.gov procedure price lookup tool, however CMS reimburses different amounts for a colonoscopy depending on whether the procedure occurred in an ambulatory surgical center or a hospital outpatient department. Further complicating the issue,

colonoscopies can be coded as screening or diagnostic, and reimbursement rates for each procedure vary. A screening test is performed when the patient is asymptomatic and carries no co-payment for the patient. A diagnostic colonoscopy occurs when a patient is either exhibiting gastrointestinal symptoms or following a positive stool-based test (Hamman and Kapinos 2015, 2070). All additional colonoscopies in this analysis would be diagnostic as they would be a follow-up to a positive stool-based test; however, diagnostic colonoscopies carry a 20 percent co-pay for beneficiaries, an additional cost to patients rather than to CMS that needed to be accounted for in cost breakdowns of the analysis.

To determine the average colonoscopy reimbursement rate, an estimate of the ratio of hospital to outpatient colonoscopies was required. Eberth et al. (2018, 139-140) performed an analysis of which settings colonoscopies took place in the state of South Carolina over a 10-year period and found 78 percent of colonoscopies took place in a hospital compared to an ambulatory service center. While these results from South Carolina may not necessarily be nationally representative, they serve as the best available estimate of the breakdown of hospital to outpatient colonoscopies. The average cost to CMS for a single follow-up colonoscopy was obtained by calculating an expected value using 2021 reimbursement rates at the setting ratios found by Eberth et al. resulting in a final obtained cost per colonoscopy to CMS of $1,180.

The Removing Barriers to Colorectal Cancer Screening act was passed in 2020 to eliminate copayments required of Medicare beneficiaries for diagnostic colonoscopies; the copays will be phased out incrementally beginning in 2024 and will be fully eliminated by 2030 (US Congress 2020). To calculate the expected annual costs borne by patients, an expected value was calculated based on the diminishing annual copayment rates set by the Removing Barriers Act and the previously calculated colonoscopy reimbursement rate. Over a 10-year period, the expected average cost of an additional diagnostic colonoscopy was $1,038 for CMS and $142 for the patient. These costs were multiplied by the expected screening uptake rate of the eligible population and then by the expected FIT positivity rate to determine the total annual cost of the additional colonoscopies to both CMS and beneficiaries.

BENEFITS

COST OF TREATMENT

One benefit to CMS is the money saved that would have been spent on CRC treatment for those who did not receive preventative intervention and were diagnosed with CRC. A study by Luo et al. (2009, 37-38) estimated the costs attributable to one year of CRC treatment for patients with Medicare. The mean total cost of CRC treatment per Medicare patient in this study was updated to 2021 dollars and this figure of $47,653 per patient was used as a measure of the benefit to CMS of money saved on CRC treatment annually per patient. This figure was not applied to all individuals in the target population but rather the percent of the target population estimated to complete their CRC screening following the intervention (29 percent based on results from Issaka et al.) and then multiplied by the expected CRC incidence rate of 37 per 100,000.

PATIENT TIME COSTS

Another benefit included in the calculations was the patient time costs of CRC. Patient time cost is the monetized value of the patient time lost to seek medical care including transportation and waiting time. Yabroff et al. (2005, 643-644) estimated these patient time costs in a study using Medicare data to determine patient time estimates and the national median wage rate from the Bureau of Labor Statistics to value patient time.

When updated to 2021 dollars, this value came to $6,801 per patient per year. It could be argued that this estimate is too high given that Yabroff et al. used national median wage data to approximate wages for a mostly retired Medicare population (643). To account for this, initial sensitivity analysis calculations included a range of values for this figure; however, these adjustments did not significantly impact the final net benefit calculations and only the estimate provided by Yabroff et al. was used in final analyses. Total expected annual benefits were calculated using the same method as previously described for treatment cost benefits.

VALUE OF STATISTICAL LIFE

As previously stated, this analysis attempted to follow the US Department of Health and Human Services Guidelines for Regulatory Impact Analysis (2017) to the maximum extent possible. In the development of these guidelines, the HHS carried out a literature review of the most relevant studies to determine how to most appropriately place a value on a human life. The published findings from this review (Robinson and Hammit 2016, 1048-1049) provide detail as to the assumptions and criteria that were used in determining appropriate Value of Statistical Life (VSL) figures for use in HHS Regulatory Impact Analysis. Both revealed preference studies and stated preference studies were included in the analysis. All studies were required to provide estimates for the general US population rather than a specific subgroup. Revealed preference studies were limited to wage-risk studies, were required to control for potential confounding factors, and had to rely on data at the quality of the Census of Fatal Occupational Injuries or better. Stated preference studies were required to assess private risk reductions rather than community risk reductions, had to be based on willingness to pay rather than willingness to accept compensation, had to express risk change as a probability, and were required to provide evidence of validity (Robinson and Hammit 2016, 1041-1043).

Based on the results of this investigation, the HHS Guidelines for Regulatory Impact Analysis (2017, 17-21) recommends using a central VSL estimate of $9.3 million, and testing sensitivity values of $4.4 million and $14.2 million. These values are in 2014 dollars and were converted into 2021 dollars to determine the value of each life saved through the implementation of this program. The HHS Central VSL figure was used in base calculations and high/low VSL estimates were used in sensitivity analysis. To determine total benefits of lives saved, the VSL was multiplied by the expected uptake population within the larger target population and then multiplied by the expected annual CRC mortality rate of 13 per 100,000.

TOTAL NET BENEFIT

Over a 10-year period, the total net benefits of this program would be $74.5 billion dollars. After subtracting the previously discussed costs from the benefits, the net benefits for this policy proposal can be calculated. Base case assumptions included a seven percent discount rate, a 29 percent screening uptake rate with an 8.3 percent FIT positivity rate, and the central VSL estimate of $15,113,050. The expected net benefit at the end of program year one, including program development costs, was found to be $9.7 billion dollars. See Appendix A for full calculations.

SENSITIVITY ANALYSIS

Due to the prospective, ex-ante nature of this analysis, this cost benefit analysis relies heavily on the use of estimates and assumptions. Though these estimates are grounded in prior research and analysis, they nonetheless remain estimates. Due to the high degree of uncertainty involved in the analysis of a program that has not yet

been implemented, the true impacts of the program will never be known ahead of time. However, the incorporation of sensitivity analyses allows for the variance of expected values of estimates to gain a greater understanding of the potential impact of the program. This study included several sensitivity analyses to account for potential variations in outcomes based on alternate inputs. These sensitivity analyses include a best-case evaluation, a worst-case evaluation, an analysis using MT-sDNA every three years rather than an annual FIT, and a final analysis which used Value of Statistical Life Years (VSLYs) rather than a VSL to calculate benefits.

Five main inputs were adjusted over the course of the sensitivity analysis to understand the potential variation of expected net benefits. Following HHS Guidelines for Regulatory Impact Analysis (2017), discount rates of three and seven percent were applied to calculations. Though the base case for expected screening uptake was grounded in prior research outcomes in the exact treatment population of this intervention, a low screening uptake rate of 15 percent and a high uptake rate of 40 percent were included in sensitivity analysis to account for potential variance in program uptake rates. Per HHS guidelines, the VSL was also evaluated at a high, central, and low figure in sensitivity analyses. The program was also evaluated with the use of MT-sDNA tests on a tri-annual basis rather than the annual use of FIT tests. Sensitivity analysis for year one program results using the central VSL can be found in Table 2. The best-case, worst-case, and MT-sDNA analyses are presented in the following.

Table 2: Sensitivity Analysis

Sensitivity Analysis: End of Program Year 1 (VSL Central) — Cost in Millions of 2021 Dollars

Description	Base Case	Discount Rate		Screening Uptake Rate	
Costs		0.03	0.07	0.15	0.40
One Time Costs					
Intervention Development	317.79	308.54	297.00	317.79	317.79
Annual Costs to Patients:					
Colonoscopy Copayment Following Positive FIT (10 yr avg)	71.85	69.75	67.15	37.16	99.10
Annual Costs to CMS:					
Annual Cost of FIT Test	335.49	325.72	313.55	335.49	325.72
Annual Intervention Admin	99.26	96.37	92.76	99.26	99.26
Annual Interventaion Delivery	437.49	424.75	408.87	437.49	437.49
CMS Colonoscopy Cost	526.89	511.54	492.42	272.53	726.74
Total Costs	1,788.77	1,736.67	1,671.74	1,499.72	2,006.10
Benefits:					
Benefits to CMS					
Money Saved on Annual CRC Treatment	107.75	104.61	100.70	55.73	148.62
Benefits to Patients					
Patient Time Cost of CRC	15.38	14.93	14.37	7.95	21.21
Benefits to Society					
Value of Statistical Lives Saved	12,008.83	11,659.06	11,223.21	6,211.46	16,563.90
Total Benefits	12,131.96	11,778.60	11,338.28	6,275.15	16,733.74
Total Net Benefit End of Year 1	10,343.19	10,041.94	9,666.54	4,775.43	14,727.64

Source: Figure prepared by the author

BEST-CASE

The best-case sensitivity analysis applied variations in the previously discussed inputs that would result in the maximum expected net benefit. This case used a discount rate of three percent, the high VSL estimate of $23,075,841, and a screening uptake rate of 40 percent. Under this best-case scenario, the expected net benefit at the end of year one was $22.8 billion dollars and the expected net benefit at the end of a 10-year period was $202.3 billion dollars. See Appendix B for full calculations.

WORST-CASE

The worst-case sensitivity analysis applied variations to the same inputs as the best case but used values that would return the minimum expected net benefit. This case used a discount rate of seven percent, the low VSL estimate of $7,150,260, and a screening uptake rate of 15 percent. Under this worst-case scenario, the expected net benefit at the end of year one was $1.4 billion dollars and the expected net benefit at the end of a 10-year period was $12.5 billion dollars. See Appendix C for full calculations.

MULTI-TARGET STOOL DNA

Further sensitivity analysis involved the use of an MT-sDNA test once every three years instead of an annual FIT. MT-sDNA test costs are significantly higher, but the three-year requirement would also result in lower administrative and implementation costs. To estimate these lower costs, the baseline administration and delivery costs were divided by three. The base expected screening uptake rate of 29 percent was used as was the central VSL and a discount rate of seven percent. An expected test positivity rate of 8.3 percent was also applied. Under this scenario using MT-sDNA tests, the expected net benefit at the end of year one was $6.9 billion dollars and the expected net benefit at the end of a 10-year period was $54.3 billion dollars. While these estimates fall below the base case scenario, this program still offers significant benefits to society. The lower net benefits found using MT-sDNA tests compared to the base case using FITs are most strongly connected to the high cost of a MT-sDNA test compared to a FIT, even when accounting for test purchase only once every three years. If the price of MT-sDNA tests drop in future, the use of a MT-sDNA test on a three-year basis may become the more efficient alternative and may be worth re-evaluating as these changes occur. Full calculations for this sensitivity analysis can be found in Appendix D.

VALUE OF STATISTICAL LIFE YEARS

Using VSL to determine the benefit of lives saved may result in an overestimation of the benefit as HHS VSLs are designed with the assumption that the benefiting individual is 40 years old. To account for this potential overestimation, a final sensitivity analysis used Value of Statistical Life Years (VSLYs) rather than VSL to calculate benefits. In 2021, the CDC estimated the average life expectancy of a 40-year-old in the United States to be 38.6 years (Arias et al. 2022, 2). To calculate a VSLY per HHS guidance, the VSL is divided by expected years remaining. For this sensitivity analysis, the central VSL estimate was used and the expected years remaining was 38.6 years, which resulted in a VSLY of approximately $390,000.

Estimating the benefit of the program using VSLYs required an estimate of the years of life lost for those with colorectal cancer compared to the rest of the population. Capocaccia, Gatta, and Dal Maso (2015, 1266) estimated the life expectancy of colon cancer patients compared to the rest of the population using US patient data and found that for those diagnosed with colon cancer at age 62, the average years lost was 6.3 for women and 5.8 for men. While 62 is three years shy of Medicare eligibility, an estimate of six years saved by avoiding colorectal cancer seemed an appropriate approximation for sensitivity analysis purposes. Based on Capocaccia, Gatta, and Dal Maso's estimates (2015), the VSLY was multiplied by the estimated six years gained by avoiding CRC resulting in a benefit of approximately $2.4 million per life saved.

Using VSLY based on VSL central estimates, the base expected screening uptake rate of 29 percent, and a discount rate of 7 percent, the expected net benefit at the end of year one was $167 million dollars and the expected net benefit at the end of a 10-year period

was $3.3 billion dollars. This sensitivity analysis indicated that even while adjusting for the potential overvaluation of a life saved based on age, the benefits of the policy clearly outweigh costs. Full calculations for this sensitivity analysis can be found in Appendix E.

DISCUSSION AND POLICY RECOMMENDATIONS

In each case, the cost-benefit analysis of a Medicare program to send at-home colorectal cancer (CRC) screening tests to Medicare beneficiaries who are not up to date with screening offered sizable net benefits to society. Under base conditions, the expected net benefits after one year of the program are estimated to be $9.65 billion dollars with a 10-year benefit of $74.5 billion. Worst-case scenario estimated net benefits after one year of the program were $1.4 billion dollars with a 10-year benefit of $12.5 billion. Under the best-case scenario, estimated net benefits after program year one were $22.7 billion dollars with a 10-year benefit of $202.4 billion. Based on these calculations, this program would result in significant dollar savings to US taxpayers but more importantly, it would result in lives saved. It also has the potential to reduce colorectal cancer disparities by providing increased access to screening for the most vulnerable populations.

Policymakers will likely balk at the high upfront costs required to roll out a program of such magnitude, however, the results of this cost-benefit analysis in tandem with the wide successes of many national level mailed-FIT programs in other countries around the globe indicate that the Centers for Medicare and Medicaid Services should seriously consider implementation of such a program. Given the high costs required to develop this program at the national level, an incremental rollout may be required to demonstrate continued effectiveness of a mailed CRC test program within the Medicare population.

The most effective course of action would likely be to begin with a Medicare Demonstration through the Center for Medicare and Medicaid Innovation (CMMI). By rolling out the program in a number of smaller regions through a CMMI demonstration project, program efficacy could be evaluated in multiple markets with a lower upfront cost burden. This would also allow CMS to evaluate heterogeneous effects of program uptake based on variations in the population and geographic characteristics of demonstration locations.

Under the status quo, CRC screening for Medicare beneficiaries is an opt-in system and at present, this system is failing as many as one-third of eligible individuals. By leveraging behavioral insights and implementing a program with a default that makes it easier to complete screenings for those who are not up to date, colorectal cancer can be prevented, and lives can be saved. This analysis demonstrates that doing so is not only feasible but would provide significant net benefits to society.

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Appendix A

Appendix A **Baseline Estimates: 7% Discount, 29% Screening uptake** **Costs in Millions of 2021 Dollars**

Costs	NPV	NPV Year 1	NPV Year 2	NPV Year 3	NPV Year 4	NPV Year 5	NPV Year 6	NPV Year 7	NPV Year 8	NPV Year 9	NPV Year 10
One Time- Costs											
Intervention Development	317.79	317.79	-	-	-	-	-	-	-	-	-
Annual Costs to Patients:											
Colonoscopy Copayment Following Positive FIT (10 yr avg)	71.85	67.15	62.75	58.65	54.81	51.23	47.87	44.74	41.82	39.08	36.52
Annual Costs to CMS:											
Annual Cost of FIT Tests	335.49	313.55	293.03	273.86	255.95	239.2	223.55	208.93	195.26	182.49	170.55
Annual Intervention Admin	99.26	92.76	86.7	81.02	75.72	70.77	66.14	61.81	57.77	53.99	50.46
Annual Intervention Delivery	437.49	408.87	382.12	357.12	333.76	311.92	291.52	272.45	254.62	237.97	222.4
CMS Colonoscopy Cost	526.89	492.42	460.2	430.1	401.96	375.66	351.09	328.12	306.65	286.59	267.84
Total Annual Costs:	1,470.97	1,692.53	1,284.81	1,200.75	1,122.2	1,048.78	980.17	916.05	856.12	800.11	747.77
Benefits:											
Benefits to CMS											
Money Saved on Annual CRC Treatment	107.75	100.7	94.11	87.96	82.2	76.82	71.8	67.1	62.71	58.61	54.77
Benefits to Patients											
Patient Time Cost of CRC	15.38	14.37	13.43	12.55	11.73	10.97	10.25	9.58	8.95	8.37	7.82
Benefits to Society											
Value of Statistical Lives Saved	12,008.83	11,223.21	10,488.98	9,802.78	9,161.48	8,562.13	8,001.99	7,478.5	6,989.25	6,532.01	6,104.68
Total Annual Benefits:	12,131.96	11,338.28	10,596.52	9,903.29	9,255.41	8,649.92	8,084.04	7,555.17	7,060.91	6,598.98	6,167.27
Present Value Annual Net Benefit		9,645.75	9,311.72	8,702.54	8,133.22	7,601.14	7,103.87	6,639.13	6,204.79	5,798.87	5,419.5
Total NPB		9,645.75	18,957.46	27,660.	35,793.22	43,394.36	50,498.22	57,137.35	63,342.14	69,141.01	74,560.51

Appendix B

Appendix B **Best Case Analysis: 3% Discount, 40% Uptake, High VSL** **Costs in Millions of 2021 Dollars**

Costs	NPV	NPV Year 1	NPV Year 2	NPV Year 3	NPV Year 4	NPV Year 5	NPV Year 6	NPV Year 7	NPV Year 8	NPV Year 9	NPV Year 10
One Time- Costs											
Intervention Development	317.79	317.79	-	-	-	-	-	-	-	-	-
Annual Costs to Patients:											
Colonoscopy Copayment Following Positive FIT (10 yr avg)	99.1	96.21	93.41	90.69	88.05	85.48	82.99	80.58	78.23	75.95	73.74
Annual Costs to CMS:											
Annual Cost of FIT Tests	335.49	325.72	316.24	307.02	298.08	289.4	280.97	272.79	264.84	257.13	249.64
Annual Intervention Admin	99.26	96.37	93.56	90.83	88.19	85.62	83.13	80.71	78.35	76.07	73.86
Annual Intervention Delivery	437.49	424.75	412.38	400.37	388.7	377.38	366.39	355.72	345.36	335.3	325.53
CMS Colonoscopy Cost	726.74	705.57	685.02	665.07	645.7	626.89	608.63	590.9	573.69	556.98	540.76
Total Annual Costs:	1,698.08	1,966.41	1,600.6	1,553.98	1,508.72	1,464.78	1,422.11	1,380.69	1,340.48	1,301.44	1,263.53
Benefits:											
Benefits to CMS											
Money Saved on Annual CRC Treatment	148.62	144.29	140.09	136.01	132.05	128.2	124.47	120.84	117.32	113.91	110.59
Benefits to Patients											
Patient Time Cost of CRC	21.21	20.59	19.99	19.41	18.85	18.3	17.77	17.25	16.75	16.26	15.78
Benefits to Society											
Value of Statistical Lives Saved	25,291.12	24,554.49	23,839.31	23,144.96	22,470.83	21,816.34	21,180.92	20,564.	19,965.05	19,383.54	18,818.97
Total Annual Benefits:	25,460.96	24,719.37	23,999.39	23,300.38	22,621.73	21,962.84	21,323.15	20,702.09	20,099.11	19,513.7	18,945.34
Present Value Annual Net Benefit		22,752.96	22,398.79	21,746.4	21,113.01	20,498.07	19,901.04	19,321.39	18,758.63	18,212.27	17,681.81
Total NPB		22,752.96	45,151.75	66,898.15	88,011.16	108,509.23	128,410.26	147,731.66	166,490.29	184,702.56	202,384.37

Appendix C

Appendix C **Worst Case Analysis: 7% Discount, 15% Uptake, Low VSL** **Costs in Millions of 2021 Dollars**

Costs	NPV	NPV Year 1	NPV Year 2	NPV Year 3	NPV Year 4	NPV Year 5	NPV Year 6	NPV Year 7	NPV Year 8	NPV Year 9	NPV Year 10
One Time- Costs											
Intervention Development	317.79	317.79	-	-	-	-	-	-	-	-	-
Annual Costs to Patients:											
Colonoscopy Copayment Following Positive FIT (10 yr avg)	37.16	34.73	32.46	30.34	28.35	26.5	24.76	23.14	21.63	20.21	18.89
Annual Costs to CMS:											
Annual cost of FIT Tests	335.49	313.55	293.03	273.86	255.95	239.2	223.55	208.93	195.26	182.49	170.55
Annual Intervention Admin	99.26	92.76	86.7	81.02	75.72	70.77	66.14	61.81	57.77	53.99	50.46
Annual Intervention Delivery	437.49	408.87	382.12	357.12	333.76	311.92	291.52	272.45	254.62	237.97	222.4
CMS Colonoscopy Cost	272.53	254.7	238.04	222.46	207.91	194.31	181.6	169.72	158.61	148.24	138.54
Total Annual Costs:	1,181.93	1,422.4	1,032.34	964.81	901.69	842.7	787.57	736.05	687.89	642.89	600.83
Benefits:											
Benefits to CMS											
Money Saved on Annual CRC Treatment	55.73	52.09	48.68	45.49	42.52	39.74	37.14	34.71	32.44	30.31	28.33
Benefits to Patients											
Patient Time Cost of CRC	7.95	7.43	6.95	6.49	6.07	5.67	5.3	4.95	4.63	4.33	4.04
Benefits to Society											
Value of Statistical Lives Saved	2,938.76	2,746.5	2,566.82	2,398.9	2,241.96	2,095.29	1,958.22	1,830.11	1,710.38	1,598.49	1,493.92
Total Annual Benefits:	3,002.44	2,806.02	2,622.45	2,450.89	2,290.55	2,140.7	2,000.66	1,869.77	1,747.45	1,633.13	1,526.29
Present Value Annual Net Benefit		1,383.62	1,590.11	1,486.08	1,388.86	1,298.	1,213.09	1,133.72	1,059.56	990.24	925.46
Total NPB		1,383.62	2,973.73	4,459.81	5,848.67	7,146.68	8,359.76	9,493.49	10,553.04	11,543.28	12,468.74

Appendix D

Appendix D **MT-sDNA Analysis: 7% Discount, 29% Uptake, Central VSL** **Costs in Millions of 2021 Dollars**

Costs	NPV	NPV Year 1	NPV Year 2	NPV Year 3	NPV Year 4	NPV Year 5	NPV Year 6	NPV Year 7	NPV Year 8	NPV Year 9	NPV Year 10
One Time- Costs											
Intervention Development	317.79	317.79	-	-	-	-	-	-	-	-	-
Annual Costs to Patients:											
Colonoscopy Copayment Following Positive FIT (10 yr avg)	71.85	67.15	62.75	58.65	54.81	51.23	47.87	44.74	41.82	39.08	36.52
Annual Costs to CMS:											
Annual Cost of MT-sDNA Tests	3,574.6	3,340.75	3,122.19	2,917.94	2,727.04	2,548.64	2,381.91	2,226.08	2,080.45	1,944.34	1,817.14
Annual Intervention Admin	33.09	30.92	28.9	27.01	25.24	23.59	22.05	20.6	19.26	18.	16.82
Annual Intervention Delivery	145.83	136.29	127.37	119.04	111.25	103.97	97.17	90.82	84.87	79.32	74.13
CMS Colonoscopy Cost	526.89	492.42	460.2	430.1	401.96	375.66	351.09	328.12	306.65	286.59	267.84
Total Annual Costs:	4,352.24	4,385.31	3,801.42	3,552.73	3,320.31	3,103.09	2,900.08	2,710.36	2,533.05	2,367.33	2,212.46
Benefits:											
Benefits to CMS											
Money Saved on Annual CRC Treatment	107.75	100.7	94.11	87.96	82.2	76.82	71.8	67.1	62.71	58.61	54.77
Benefits to Patients											
Patient Time Cost of CRC	15.38	14.37	13.43	12.55	11.73	10.97	10.25	9.58	8.95	8.37	7.82
Benefits to Society											
Value of Statistical Lives Saved	12,008.83	11,223.21	10,488.98	9,802.78	9,161.48	8,562.13	8,001.99	7,478.5	6,989.25	6,532.01	6,104.68
Total Annual Benefits:	12,131.96	11,338.28	10,596.52	9,903.29	9,255.41	8,649.92	8,084.04	7,555.17	7,060.91	6,598.98	6,167.27
Present Value Annual Net Benefit		6,952.97	6,795.1	6,350.56	5,935.11	5,546.83	5,183.95	4,844.82	4,527.86	4,231.65	3,954.81
Total NPB		6,952.97	13,748.07	20,098.64	26,033.75	31,580.57	36,764.53	41,609.34	46,137.21	50,368.86	54,323.67

Appendix E

Appendix E **VSLY: 7% Discount, 29% Screening uptake** **Costs in Millions of 2021 Dollars**

Costs	NPV	NPV Year 1	NPV Year 2	NPV Year 3	NPV Year 4	NPV Year 5	NPV Year 6	NPV Year 7	NPV Year 8	NPV Year 9	NPV Year 10
One Time- Costs											
Intervention Development	317.79	317.79	-	-	-	-	-	-	-	-	-
Annual Costs to Patients:											
Colonoscopy Copayment Following Positive FIT (10 yr avg)	71.85	67.15	62.75	58.65	54.81	51.23	47.87	44.74	41.82	39.08	36.52
Annual Costs to CMS:											
Annual Cost of FIT Tests	335.49	313.55	293.03	273.86	255.95	239.2	223.55	208.93	195.26	182.49	170.55
Annual Intervention Admin	99.26	92.76	86.7	81.02	75.72	70.77	66.14	61.81	57.77	53.99	50.46
Annual Intervention Delivery	437.49	408.87	382.12	357.12	333.76	311.92	291.52	272.45	254.62	237.97	222.4
CMS Colonoscopy Cost	526.89	492.42	460.2	430.1	401.96	375.66	351.09	328.12	306.65	286.59	267.84
Total Annual Costs:	1,470.97	1,692.53	1,284.81	1,200.75	1,122.2	1,048.78	980.17	916.05	856.12	800.11	747.77
Benefits:											
Benefits to CMS											
Money Saved on Annual CRC Treatment	107.75	100.7	94.11	87.96	82.2	76.82	71.8	67.1	62.71	58.61	54.77
Benefits to Patients											
Patient Time Cost of CRC	15.38	14.37	13.43	12.55	11.73	10.97	10.25	9.58	8.95	8.37	7.82
Benefits to Society											
VSLYs Saved	1,866.66	1,744.54	1,630.41	1,523.75	1,424.06	1,330.9	1,243.83	1,162.46	1,086.41	1,015.34	948.91
Total Annual Benefits:	1,989.79	1,859.61	1,737.96	1,624.26	1,518.	1,418.69	1,325.88	1,239.14	1,158.07	1,082.31	1,011.51
Present Value Annual Net Benefit		167.08	453.15	423.51	395.8	369.91	345.71	323.09	301.95	282.2	263.74
Total NPB		167.08	620.23	1,043.74	1,439.54	1,809.45	2,155.15	2,478.24	2,780.2	3,062.4	3,326.14