Comparison of Program Resources Required for Colonoscopy and Fecal Screening: Findings From 5 Years of the Colorectal Cancer Control Program

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Methods
We collected cost data from 29 Centers for Disease Control and Prevention Colorectal Cancer Control Program (CRCCP) grantees by using a standardized data collection instrument for 5 program years (2009–2014). We created a panel data set with 124 records and assessed differences by screening test used.

Results
Forty-four percent of all programs (N = 124) offered colonoscopy (55 of 124), 32% (39 of 124) offered FOBT/FIT, and 24% (30 of 124) offered both. Overall, total cost per person was higher in program year 1 ($3,962), the beginning of CRCCP than in subsequent program years ($1,714). The cost per person was $3,153 for programs using colonoscopy and $1,291 for those using FOBT/FIT with diagnostic colonoscopy. The average clinical cost per person was $1,369 for colonoscopy and $280 for FOBT/FIT during the program (these do not reflect cost of repeated FOBT/FIT screens). Programs serving a large number of people had lower per-person costs than those serving a small volume, probably because of fixed costs related to nonclinical expenses.

Conclusion
Colorectal cancer screening programs incur costs in addition to the clinical cost of the screening procedures to support planning and management, contracting with providers, and tracking patients. Because programs can achieve potential economies of scale, partnerships among smaller programs for screening delivery could decrease overall costs.

Introduction
Colorectal cancer screening programs incur costs in addition to the clinical cost of the screening procedures to support planning and management, contracting with providers, and tracking patients. Because programs can achieve potential economies of scale, partnerships among smaller programs for screening delivery could decrease overall costs.
Program staff members allocated these costs to screening activities, labor costs, nonlabor costs, and in-kind contributions for each activity for each grantee by year. Summaries of these data were sent to grantees annually for their review and approval.

The total sample size available for analysis was 124 program years over the 5-year period. We created a panel data set, which included each year of the program as 1 entry, and we reported our sample size in program years. Massachusetts (all years) and the Alaska Native Tribal Health Commission (all years) were excluded from the analyses because we were unable to disaggregate the clinical and nonclinical costs from contract payments in sufficient detail. Alabama, California, Iowa, New Mexico, and Oregon were all excluded in year 1 because they had not yet begun activities; Georgia, Michigan, and Nevada were not included in year 1 because they had not yet begun CRCCP. Georgia was also excluded from year 2 and Oregon from years 2 and 3 because their screening activities had not yet commenced during those years.

### Descriptive analyses

We stratified the programs by type of screening test used: colonoscopy, FOBT/FIT, and programs that used both tests. Fecal tests that include FOBT and FIT were offered as screening tests, and colonoscopy was offered as screening and for follow-up diagnostic procedures. Programs with both tests offered both fecal tests and colonoscopy for colorectal cancer screening. Some programs also offered surveillance colonoscopies, and these were reported separately from screening colonoscopies.

We identified key characteristics of the program, including the region and number of people served by the program, which was categorized as large (>500), medium (235–500), and small (<235) on the basis of the distribution of the underlying data. We also reported screening and diagnostic procedures for each type of program, including number of people who were screened or received surveillance colonoscopies, number of diagnostic procedures, and number of people identified with polyps. Use rates for the procedures were derived from information provided in CRCCP-CAT and from CRC clinical data elements that were collected from all programs by CDC (Office of Management and Budget [OMB] control no. 0920–0745).

We stratified cost information by the following activities: 1) direct clinical activities, such as provision of screening tests, diagnostic services, and surveillance procedures; 2) direct nonclinical...
al activities, such as managing provider contracts and billing systems; and 3) indirect nonclinical overarching activities, such as program management and administration (Box).

| Box, Component Activities of the Colorectal Cancer Control Program, 2009–2014 |
|---|
| **Direct clinical activities** |
| Screening and diagnostic services |
| Surveillance procedures |
| **Direct nonclinical activities** |
| Provider contracts, billing systems, other billing procedures |
| Patient navigation and support |
| Labor costs for screening and diagnostic services (if reported) |
| Ensure cancer treatment |
| Other screening provision activities |
| **Indirect nonclinical overarching activities** |
| (related to both screening promotion and screening procedures) |
| Program management |
| Quality assurance/professional development |
| Partnership development and maintenance |
| Clinical and cost data collection and tracking |
| Program monitoring and evaluation |
| Administration |
| Other activities |

We calculated the cost per person aggregated across all program years and the cost for each program year to examine patterns across the 5-year period. We estimated adjusted costs (multivariate regression controlling for region, size of population served, and type of screening test) for total cost per person for direct clinical costs, direct nonclinical costs, and indirect costs. We estimated the average incremental effect on cost of each explanatory variable as the difference from one of the exponentiated coefficients and multiplying by the mean of the variable. Cost data were adjusted for regional differences by using the Bureau of Labor Statistics’ Employment Cost Index.

**Multivariable regression specification**

We used multivariate analysis to assess the effect of volume of people screened on cost per person. We examined the total cost per person served by 3 cost components: total direct clinical cost, total direct nonclinical cost, and total indirect cost (12–14). Results of a Hausman test indicated that a fixed effects model was not appropriate for this panel data and that a mixed effects model should be used (15). We used a generalized linear model (GLM) with log link and specified a gamma distribution. We included data for years 2 to 5 in the regression estimation. We excluded year 1 because this was the start-up period, anticipating that costs for this year would differ from other program years.

GLM with log link allowed us to exponentiate the coefficient estimates without the need for a retransformation as is required when estimating a log-linear model. Regression results were tabulated in terms of the incremental effect on average cost. We used the Stata statistical package, version 14.0 (StataCorp LLC) to conduct all regression analyses and statistical tests of the model.

**Results**

Overall, 44.4% (55 of 124) of the programs assessed used colonoscopy as the primary screening test; 31.5% (n = 39) used FOBT/FIT, and 24.2% (n = 30) used both tests (Table 1). Of the programs that offered colonoscopy as the primary screening test, the greatest percentage (36.4%; n = 20) was in the Northeast, whereas of the 39 programs that offered FOBT/FIT as the primary screening test, most (61.5%; n = 24) were in the West. Forty-three percent (13 of 30) of the programs offering both tests were also located in the West. Programs offering FOBT/FIT and both types of tests were more likely to serve a large population (FOBT/FIT, 46.2% [18 of 39]; both tests, 63.3% [19 of 30]) than colonoscopy programs (10.9% [6 of 55]). On average, grantees using both tests screened 2,152 people over the 5-year period, followed by grantees using FOBT/FIT (683 people) and grantees using colonoscopy (254 people). We also assessed program testing method by program characteristics (Table 2).

Overall, total cost per person decreased from year 1 ($3,962) to year 5 ($1,841); average cost across years 2,3,4, and 5 was $1,714. On average, the cost per person was highest in year 1 for each component. For example, in year 1, direct clinical cost per person was $1,068, decreasing in year 2 to $793, and remaining similar over the remaining years (Figure). Overall, the cost per person was high in year 1 compared with years 2 through year 5 for each component.
Cost per person by type of screening test varied significantly across the 3 test types (Table 3). On average, screening tests cost $2,060 per person, ranging from $1,057 for both tests to $3,153 for colonoscopy. All components were, on average, most expensive for colonoscopy programs; total costs per person were $1,369 for direct clinical costs, $863 for nonclinical costs, and $921 for indirect costs. By comparison, total cost per person for FOBT/FIT were $280 for direct clinical costs, $375 for direct nonclinical costs, and $636 for indirect costs. Total per person costs for both tests were $411 for direct clinical costs, $173 for direct nonclinical cost was, and $473 for indirect cost.

Examining the estimates for adjusted total cost per person, we found that programs using colonoscopy screening had an average $1,104 higher total cost per person served compared with programs using FOBT/FIT tests in years 2 through 5 (Table 4). Increased size of the population served lowered total cost significantly; in years 2 through 5, average costs for programs with medium populations were $899 lower than programs with small populations served, and programs with large populations were $1,313 lower.

The total number of people screened had some effect on the direct clinical cost per person; programs with large populations screened had $292 lower costs than programs with small populations screened. Colonoscopy programs had a higher direct clinical cost than FOBT/FIT programs ($2,365 higher).

Our estimates for total direct nonclinical cost per person served show that type of screening test did not affect direct nonclinical costs (Table 4). Similar to total costs, costs for programs with large populations served were $352 lower than programs with small populations served, whereas costs for programs with medium populations served were $270 lower.

We also found that total indirect cost per person served was significantly lower among programs with larger populations served (Table 4). The average indirect cost per person served was $467 lower among programs with a large population served and $320 lower among programs with a medium population served, compared with programs with a small population served. Region also significantly affected these costs. Programs in the Northeast had an average $179 lower indirect cost per person served than programs in the South.

Discussion

We compared the clinical and nonclinical costs across program years among CRCCP grantees offering colonoscopy, FOBT/FIT, or both tests for CRC screening. Our findings expand on our prior analysis and use 5 years of data to quantify the presence of economies of scale — programs that screen a larger number of people had lower cost per person than programs that screen a smaller number of people. After controlling for type of screening test, programs serving large and medium-size populations had per-person costs that were about $1,300 and $900 lower, respectively, than programs serving small populations.

Another key finding from our study was that public health–led CRCCP programs incurred substantial nonclinical costs. These costs are important to consider when planning future programs. On average, these costs were lower for programs with large patient volumes than for programs with small patient volumes. These findings indicate that substantial fixed costs are associated with nonclinical activities. These results are further evidence that economies of scale exist in CRC screening programs, as reported in other studies (2–4).

Analysis of patterns in cost per person indicated differences in cost between the first year and subsequent years of the program. The average cost per person served in the first year was twice that of the other years. This higher cost in the first year likely reflects startup costs incurred by the programs while planning and beginning implementation. Furthermore, the number of people screened was generally lower in the first year. Any nonclinical costs incurred in the first year would have to be distributed across a much smaller cohort. High startup costs in the initial years of the program were also reported in other studies (3,16,17), suggesting that first-year costs should perhaps be analyzed separately and not pooled with costs incurred in subsequent program years.

Additionally, we identified some differences across programs related to type of screening test used. The clinical cost of colonoscopy was almost 5 times the cost of FOBT/FIT per person when screening and diagnostic follow-up tests were included. Therefore, programs that use colonoscopy will only be able to screen about...
Our analysis of the activity-based cost data across 5 years of the CRCCP reveals potential economies of scale: programs with larger screening volume incurred a lower cost per person served than smaller-volume programs. Therefore, encouraging partnerships to foster large-scale programs could be more efficient than funding multiple small screening programs. Additionally, CRC screening programs incur substantial nonclinical costs, regardless of type of test the program offers. Future CRC control programs might consider both these clinical and nonclinical costs when planning program implementation and evaluating program cost-effectiveness.

Acknowledgments

Funding support for Sujha Subramanian, Sonja Hoover, and Maggie Cole-Beebe was provided by the CDC (contract no. 200-2008-27958, Task order 01) to RTI International. The provision of data by grantees was supported through funding under a cooperative agreement with CDC. No copyrighted material, surveys, instruments, or tools were used in this manuscript. The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of CDC.

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### Table 1. Program Characteristics and Clinical Services by Type of Primary Screening Test for All Program Years, Centers for Disease Control and Prevention

| Characteristic                           | All (N = 124) | By Type of Test       | Colonoscopy and FOBT/FIT (n = 30) |
|------------------------------------------|---------------|-----------------------|----------------------------------|
|                                          |               | Colonoscopy (n = 55)  | FOBT/FIT (n = 39)                | Colonoscopy and FOBT/FIT (n = 30) |
| By screening test                        | NA            | 44.4                  | 31.5                             | 24.2                             |
| Region, mean (95% confidence interval)   |               |                       |                                  |                                  |
| Northeast                                | 20.2 (13.0–27.3) | 36.4 (23.2–49.5)    | 0 (0.0–4.0)                     | 16.7 (2.5–30.8)                  |
| Midwest                                  | 18.6 (11.6–25.5) | 9.1 (1.3–16.9)       | 28.2 (13.4–43.0)                | 23.3 (7.3–39.4)                  |
| South                                    | 17.7 (10.9–24.6) | 23.6 (12.1–35.2)     | 10.3 (0.3–20.2)                 | 16.7 (2.5–30.8)                  |
| West                                     | 43.6 (34.7–52.4) | 30.9 (18.3–43.5)     | 61.5 (45.6–77.5)                | 43.3 (24.5–62.2)                 |
| Size of population screened by program size, mean (95% confidence interval) | | | |
| Large population                         | 34.7 (26.2–43.2) | 10.9 (2.4–19.4)      | 46.2 (29.8–62.5)                | 63.3 (45.0–81.6)                 |
| Medium population                        | 36.3 (27.7–44.9) | 45.5 (31.9–59.0)     | 38.5 (22.5–54.4)                | 16.7 (2.5–30.8)                  |
| Small population                         | 29.03 (20.93–37.13) | 43.6 (30.1–57.2)    | 15.4 (3.5–27.2)                 | 20.0 (4.8–35.2)                  |
| Program reach, mean (95% confidence interval) | 848.0 (540.8–1,155.3) | 253.9 (208.6–299.2) | 683.3 (518.5–848.1)             | 2151.5 (981.6–3321.4)            |
| No. of people screened                   | 23.5 (15.8–31.2) | 15.7 (9.3–22.0)      | 21.3 (11.9–30.8)                | 40.8 (13.4–68.1)                 |
| No. of people under surveillance         | 41.3 (25.1–57.5) | 7.3 (5.2–9.4)        | 44.2 (29.9–58.5)                | 99.9 (38.7–161.0)                |
| No. of diagnostic tests performed        | 47.5 (41.0–54.1) | 61.4 (50.7–72.0)     | 27.2 (20.0–34.4)                | 48.6 (35.1–62.1)                 |

Abbreviation: FOBT/FIT, fecal occult blood test/fecal immunochemical test; NA, not applicable.

- Unit of analysis is program year. Total sample size available for analysis was 124 program years over the 5-year period. We used the $\chi^2$ test to test for differences across the types of colorectal cancer screening tests.
- $P <.001$.
- $P <.05$.
- Small population = 228,339–736,635; medium population = 854,624–1,618,255; large population = 1,749,719–9,472,316.
Table 2. Program Testing Method by Program Characteristics, Centers for Disease Control and Prevention Colorectal Cancer Control Program, 2009–2014<sup>a</sup>

| Characteristic          | Colonoscopy | FOBT/FIT | Colonoscopy and FOBT/FIT |
|-------------------------|-------------|----------|--------------------------|
| **Region**              |             |          |                          |
| Northeast (n = 20)      | 80.0 (60.8 to 99.2) | 0        | 20.0 (7.9 to 39.2)       |
| Midwest (n = 20)        | 20.0 (0.8 to 39.2)   | 50.0 (6.0 to 74.0) | 30.0 (8.0 to 52.0)       |
| South (n = 19)          | 57.9 (33.5 to 82.3)  | 21.15 (0.9 to 41.2) | 21.1 (0.9 to 41.2)       |
| West (n = 46)           | 30.4 (16.6 to 44.3)  | 47.8 (32.8 to 62.8) | 21.7 (9.4 to 34.1)       |
| **Population density**  |             |          |                          |
| Large population (n = 38)| 13.2 (1.9 to 24.4) | 42.1 (25.7 to 58.6) | 44.7 (28.2 to 61.3)      |
| Medium population (n = 43)| NA          | 34.9 (20.0 to 49.7) | 9.3 (0.3 to 18.4)        |
| Small population (n = 24)| 66.7 (46.3 to 87.0) | 20.8 (3.3 to 38.4) | 12.5 (−1.8 to 26.8)      |

Abbreviation: FOBT/FIT, fecal occult blood test/fecal immunochemical test; NA, not applicable.

<sup>a</sup> Values are percentage (95% confidence interval).
Table 3. Cost per Person Screened by Type of Primary Test, Centers for Disease Control and Prevention Colorectal Cancer Control Program, 2009–2014

| Type of Cost<sup>a</sup> | All                                      | By Type of Test          | Colonoscopy | FOBT/FIT | Colonoscopy and FOBT/FIT |
|-------------------------|-----------------------------------------|--------------------------|-------------|----------|--------------------------|
| Total cost per person<sup>b</sup> | 2,060 (1,565–2,556)                      |                          | 3,153 (2,175–4,132) | 1,291 (787–1,794) | 1,057 (631–1,482) |
| Total direct clinical cost per person<sup>b</sup> | 795 (631–958)                            |                          | 1,369 (1,069–1,669) | 280 (216–343) | 411 (283–539) |
| Total direct nonclinical cost per person<sup>b</sup> | 543 (260–826)                            |                          | 863 (261–1,465)  | 375 (87–663) | 173 (50–295) |
| Total indirect cost per person<sup>b</sup> | 723 (535–912)                            |                          | 921 (552–1,290)  | 636 (390–882) | 473 (238–708) |

Abbreviation: FOBT/FIT, fecal occult blood test/fecal immunochemical test.

<sup>a</sup>All costs include in-kind contributions and were adjusted by using the Employment Cost Index for regional differences. Values are US dollars (95% confidence interval).

<sup>b</sup>P <.001. We used the χ<sup>2</sup> test to test for differences across the types of CRC screening tests.
Table 4. Adjusted Cost per Person Screened, Years 2 to 5, Centers for Disease Control and Prevention Colorectal Cancer Control Program, 2009–2014

| Variable                          | Total Per Person | Direct Clinical | Direct Nonclinical | Indirect          |
|----------------------------------|------------------|-----------------|--------------------|-------------------|
| **Region**                       |                  |                 |                    |                   |
| South                            | (95) (−550 to 537) | (122) (−355 to 251) | 70 (−177 to 587) | (179) (−301 to −2) |
| Northeast                        | (31) (−513 to 642) | 28 (−274 to 524) | (6) (−218 to 447) | (76) (−231 to 150) |
| Midwest                          | (318 (−179 to 976) | (16) (−254 to 337) | 222 (−77 to 797) | 90 (−89 to 336)   |
| West                             |                  |                 |                    |                   |
| Size of population served by the program<sup>c</sup> |                  |                 |                    |                   |
| Small population served          |                  |                 |                    |                   |
| Large population served          | −1,313 (−1,412 to −1181) | −292 (−445 to −62) | −352 (−377 to −302) | −467 (−495 to −429) |
| Medium population served         | −899 (−1,098 to −636) | −118 (−325 to 192) | −270 (−333 to −150) | −320 (−388 to −226) |
| Screening test                   |                  |                 |                    |                   |
| FOBT/FIT                         |                  |                 |                    |                   |
| Colonoscopy                      | 1,104 (439 to 1,974) | 2,365 (1 to 319 to 940) | 76 (−139 to 469) | −64 (−196 to 115) |
| FOBT/FIT and colonoscopy         | −215 (−563 to 237) | 249 (−49 to 675) | −108 (−245 to 151) | −139 (−252 to 15) |

Abbreviation: FOBT/FIT, fecal occult blood test/fecal immunochemical test.

<sup>a</sup> All costs include in-kind contributions and were adjusted by using the Employment Cost Index for regional differences. All estimates are based on multivariate analysis; each column is a separate regression. Values are dollars (95% confidence interval). Results are for years 2–5 (N = 105).

<sup>b</sup> P < .05.

<sup>c</sup> Small population = < 235; medium population = 235–500; large population = > 500.

<sup>d</sup> P < .001.