




Assessing adherence and cost-benefit of colorectal cancer screening for accountable providers

Trace Heavener, DO^a , Frank W. McStay, MPA^b, Victoria Jaeger, DO^a , Kristen Stephenson, MD^a, Lauren Sager, MS^c, and James Sing, DO^d 

^aDepartment of Internal Medicine, Baylor Scott & White Medical Center–Temple, Temple, Texas; ^bCenter for Healthcare Policy, Baylor Scott & White Medical Center–Temple, Temple, Texas; ^cOffice of Biostatistics, Baylor Scott & White Medical Center–Temple, Temple, Texas; ^dDepartment of Gastroenterology, Baylor Scott & White Medical Center–Temple, Temple, Texas

ABSTRACT

The objective of this study was to assess adherence and costs-benefits of colorectal cancer (CRC) screenings from an accountable care organization/population health perspective. We performed a retrospective review of 94 patients (50–75 years of age) in an integrated safety net system for whom fecal CRC screening was abnormal for the period of June 1, 2014, to June 1, 2016. A cost-benefit model was constructed using Medicare payment rates and a sensitivity analysis. Most patients included in the study (64/94, 68%) received or were offered a colonoscopy. Of those receiving a colonoscopy, 24 of 45 (53%) had an abnormal finding. Total direct medical costs avoided by screening the patient panel was \$32,926 but could have exceeded \$63,237 had more patients received follow-up colonoscopies. A sensitivity analysis with 1000 patients demonstrated total monetary benefits between \$2.2 million and \$8.16 million when follow-up and colonoscopy rates were allowed to vary. Although the resulting rates of follow-up were within the range reported in the literature, there is room for improvement, especially considering the monetary benefit that could be used on other diseases. Health systems and payers should work cooperatively to structure payment models to better incentivize CRC screenings.

KEYWORDS Colorectal cancer screening; cost-benefit model; preventive care

An estimated 95,520 cases of colorectal cancer (CRC) occur annually in the USA. CRC is the second leading cause of cancer deaths, with an estimated 50,260 per year, and is one of the most costly types of cancer, with nearly \$14 billion spent on direct medical care in 2010.^{1–4} Costs of CRC the first year after diagnosis are estimated to range from \$12,757 to \$58,704 depending on comorbidities, stage, location, and other factors.^{4–9} Evidence suggests that screening—invasive exams, like colonoscopy, and noninvasive stool tests, like fecal immunochemical test (FIT)—reduces CRC incidence and mortality and is cost effective.^{2,10–15} Patients are more likely to complete screening when FIT is recommended or when given a choice between fecal methods and colonoscopy, but the rate of diagnostic colonoscopy after an abnormal fecal test result ranges from 42% to 83%.^{16–36} Improving follow-up after abnormal FIT represents a significant population

health opportunity in reducing incidence, mortality, and costs. The goal of this study was to create a theoretical understanding of how accountability through cost avoidance could be included in the development of a new payment and delivery model. Using data from an integrated delivery system in Central Texas and a cost-benefit model (CBM), this study assessed how adherence to CRC screenings could influence the allocation of resources from CRC treatment to other health initiatives.

METHODS

In this retrospective electronic medical record review, the initial search screened for patients aged 50 to 75 years who completed FIT between June 1, 2014, and June 1, 2016 (*Figure 1*). Exclusion criteria were (1) not having an assigned primary care physician, (2) having a positive FIT test or colonoscopy within the year prior to completion of the FIT test

Corresponding author: Trace Heavener, DO, Department of Internal Medicine, Baylor Scott & White Medical Center–Temple, 2401 S. 31st St., Temple, TX 76508 (e-mail: Traceheavenerdo@gmail.com)

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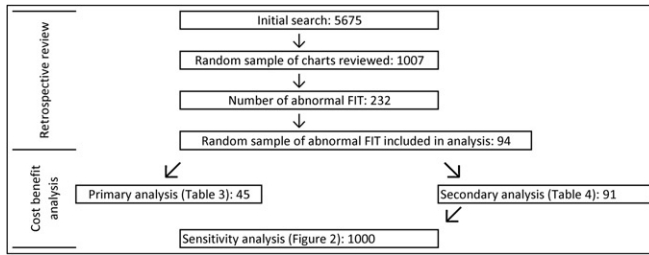


Figure 1. Populations used for retrospective review and cost-benefit analysis.

results used for this study, and (3) dying within the follow-up period. Two authors independently screened patient charts and abstracted the following data: order date for FIT in outpatient setting, electronic documentation of communicating abnormal results to the patient, the ordering of and completion of diagnostic colonoscopy, the ordering of and completion of gastroenterology clinic visit, and the time to and results of diagnostic colonoscopy. Additionally, the following demographic and protected health information data were extracted: age, gender, ethnicity, insurance status, ZIP code, and previously positive FIT. This was an exploratory investigation, so a smaller sample was used as a proof of concept. Simple random sampling was conducted and used to explore the relation between abnormal FIT tests and rate of follow-up within 1 year. Measures of central tendencies were used to describe results.

A CBM explored the relation between monetary benefit of screening adherence via the (1) follow-up rate after abnormal FITs and (2) rate of colonoscopies after abnormal FITs. The primary outcome of interest was total monetary benefit in terms of avoided direct medical costs within 1 year of diagnosis, less the cost of screening, complications, and missed incidences. A population health perspective was chosen because health systems are increasingly taking accountability for a population, and assessing the monetary impact of various innovations on a population is an important tool for investment purposes. Additionally, the analysis focused on initial treatment costs instead of continuing, last year of life, or lifetime costs for two primary reasons: (1) annual FIT screening aligns with first-year costs and (2) payment model performance is typically calculated annually and therefore aligns with annual screening.

Financial calculations were carried out in a separate Excel file. Medicare's 2017 physician, clinical diagnostic library, and anesthesia fee schedules were used with national payment instead of geographic-specific amounts (Table 1). The most frequent complications and rates associated with colonoscopy were estimated with diagnosis-related group codes using the Texas PricePoint tool (Table 1).^{37,38} Authors identified six CRC treatment cost studies, inflated the average reported in the studies to 2017 dollars using the Consumer Price Index, and calculated the mean cost.^{38,39} The cost of distant (stages 3 and 4) CRC (\$42,039.70) treatment was adjusted downward, as demonstrated by Zhehui et al, to

Table 1. Breakdown of costs and benefits of screening for and treating colorectal cancer

Variable	Amount
Costs^a	
Colonoscopy with foreign body removal	\$416.31
Colonoscopy with biopsy	\$412.72
Colonoscopy with lesion removal	\$457.94
Diagnostic colonoscopy	\$322.64
Colonoscopy with polypectomy	\$357.45
Tissue exam by pathologist (per jar/specimen)	\$69.62
Fecal blood screen immunoassay	\$21.82
Anesthesia low intestine scope	\$198.41
Complication: perforation (DRG 921, incidence 0.19/1000)	\$26,159.00
Complication: gastrointestinal bleeding with and without transfusion (DRG 921, incidence 0.79 and 1.59/1000, respectively)	\$26,159.00
Complication: diverticulitis (DRG 329, incidence 0.23/1000)	\$19,029.00
Complication: angina or myocardial infarction (DRG 281, incidence 0.56/1000)	\$31,352.00
Complication: stroke or transient ischemic attack (DRG 062, incidence 0.33/1000)	\$53,452.00
Other complication requiring observation (DRG 99219, incidence 0.09/1000)	\$138.60
Benefits	
Direct medical CRC costs avoided ^b	\$42,039.70

CRC indicates colorectal cancer; DRG, diagnosis-related group.

^aValues calculated from 2017 Medicare physician, clinical diagnostic lab, and anesthesia fee schedules without geographic adjustments. DRG values calculated from Texas Hospital PricePoint tool.

^bMedian cost calculated from literature review and inflated and standardized dollars.

obtain the cost of local (stages 1 and 2) CRC treatment by 0.9204.⁴⁰ In constructing the CBM, multiple assumptions were made and are listed under corresponding tables. Further, dysplastic polyps were categorized as local CRC, adenomatous polyps were estimated to have a 25% annualized risk of progression to CRC, and hyperplastic polyps were estimated to have a negligible risk of progression to CRC.⁴¹⁻⁴⁷ Findings from the quality improvement/statistical analysis were used to inform the cost-benefit analysis.

A sensitivity analysis was conducted to investigate the robustness of benefit generated (Figure 2). In the first simulation, we allowed the rate of follow-ups to vary between 55% and 85%, holding all other variables constant. In the second simulation, we allowed both the rate of follow-up and the rate of follow-up colonoscopies to vary between 55% and 85% and 65% and 90%, respectively. In addition, the second simulation allowed the rate of complications to vary between the bounds of the confidence intervals of their incidence rates based on the literature.³⁸ In both simulations,

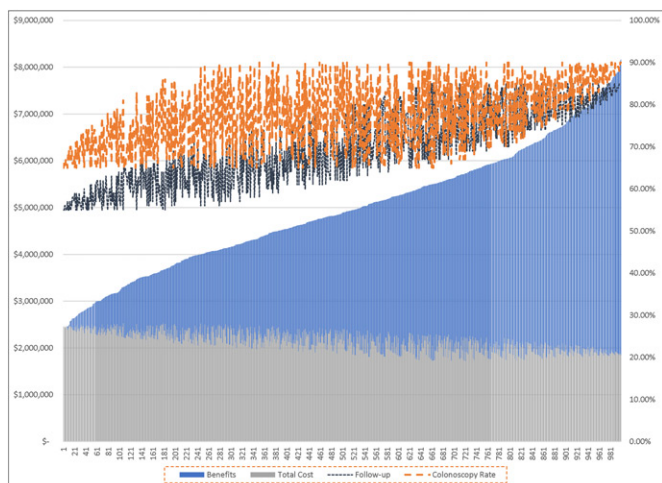


Figure 2. Sensitivity analysis with varied rates of follow-up, colonoscopies, and complications. Total costs represent the cost of screening, treatment, and complications, and total benefits represent avoided cancer costs achieved through adherence. As the adherence to screening and appropriate follow-up improves across a population, total cancer costs avoided (i.e., benefit) increase.

the panel of patients was grown from 94 to 1000 patients to better fit rates of complications.

RESULTS

The initial search revealed 5675 FITs with results that were randomized and divided among the abstractors (*Table 2, Figure 1*). Of these, 1007 charts were screened for abnormal results, revealing 232 abnormal FIT results. The first 94 charts with an abnormal FIT test that were ordered for colonoscopy screening were included in this analysis.

In total, 64 of the 94 patients received appropriate follow-up care; however, less than half (45/94, 47.87%) of all patients received a follow-up diagnostic colonoscopy. Sixteen of the 94 patients (17.02%) received communication regarding abnormal results and were offered a colonoscopy but declined. Three of the 94 patients (3.19%) received communication regarding abnormal results, but health precluded them from being offered a colonoscopy. Other results are indicated in *Table 2*.

Approximately one-half of colonoscopies (24/45, 53.33%) had an abnormal colonoscopy finding, with 3/24 (12.5%) dysplastic polyps, 14/24 (58.33%) adenomatous polyps, and 7/24 (29.17%) hyperplastic polyps. Among the three patients with dysplastic polyps, one was eventually diagnosed as a stage 3 malignancy after a wait of 90 days from abnormal FIT to diagnostic colonoscopy. Another was diagnosed as a stage 4 malignancy after a 719-day wait from positive FIT to diagnostic colonoscopy. The third case of dysplastic polyp was attributed to hemorrhoids; when the patient presented with a complaint of anemia with unintentional weight loss approximately 2 years following the abnormal FIT, the diagnostic colonoscopy was performed.

Table 2. Breakdown of included patients

Variable	N
Total FITs ordered June 2014–2016	5675
Charts screened for abnormal results	1007
Total abnormal results found	232 (23.0%)
Charts reviewed	94
Median age (years)	64.5
Female	51 (54.3%)
White	65 (69.2%)
Black	17 (18.1%)
Other/unknown	12 (12.8%)
Received follow-up care	64 (68.1%)
Received follow-up colonoscopy	45 (47.9%)
Declined colonoscopy	16 (17.0%)
Health precluded colonoscopy	3 (3.2%)
Did not receive appropriate follow-up care	30 (31.9%)
No/inadequate communication of FIT results to patient	19 (20.2%)
Repeat FIT ordered	7 (7.5%)
Colonoscopy supposedly obtained elsewhere but no records in our EMR	2 (2.1%)
Lacked transportation to colonoscopy	2 (2.1%)

EMR indicates electronic medical record; FIT, fecal immunochemical test.

The primary CBM demonstrated a population health benefit of \$32,926 in the annual screening by avoiding possible CRC (*Table 3*). The largest cost components of CRC screenings were the average cost of a colonoscopy with any intervention (\$9441) and anesthesia (\$8928). The two patients diagnosed with distant CRC contributed an estimated \$84,079.40 to costs. Total direct medical costs avoided by screening the 94-patient panel was \$189,178, which was generated by 1 dysplastic plus 3.5 adenomatous (14 patients multiplied by 25% estimated rate of progression to malignancy as described in Methods section) for 4.5 total patient equivalents who received a colonoscopy after an abnormal FIT and had adenomatous polyps removed.

A secondary CBM was performed to ascertain the possible maximum benefits and costs for the studied panel of patients (*Table 4*). In this evaluation, each of the 91 patients received a colonoscopy (excluding an equal proportion of patients who would not be healthy enough for the procedure), and equal proportions from the improvement analysis were assumed to have abnormal colonoscopies. The costs associated with the expected number of patients with pre-existing local or distant CRC were added to the costs side of the model. Specifically, 53.33% of the 91 patients receiving a colonoscopy would have abnormal findings, meaning that

Table 3. Cost-benefit analysis of patient panel with actual follow-up rate^a

Variable	Unit cost	Units	Total
Costs of CRC screenings			
FIT screening	\$21.82	94.00	(\$2051.08)
Diagnostic colonoscopy	\$322.64	21.00	(\$6775.44)
Colonoscopy with intervention	\$357.41	24.00	(\$8577.81)
Anesthesia for low intestine	\$198.41	45.00	(\$8928.45)
Pathology	\$69.62	33.60	(\$2339.23)
Complication (perforation)	\$26,159.00	0.01	(\$223.66)
Complication (bleeding, hospitalization)	\$26,159.00	0.07	(\$1871.68)
Complication (bleeding, transfusion)	\$26,159.00	0.04	(\$929.95)
Complication (diverticulitis, hospitalization)	\$19,029.00	0.01	(\$196.95)
Other GI complication (observation)	\$138.60	0.00	(\$0.56)
Angina or myocardial infarction	\$31,352.00	0.03	(\$790.07)
Stroke or transient ischemic attack	\$53,452.00	0.01	(\$793.76)
Total			(\$33,478.65)
Costs of CRC			
Direct initial CRC costs (distant-stage CRC)	\$42,039.70	2.00	(\$84,079.40)
Direct initial CRC costs (local-stage CRC)	\$38,694.28	1.00	(\$38,694.28)
Total			(\$122,773.68)
Total costs			(\$156,252.32)
Benefits of CRC screening			
Direct initial CRC costs avoided	\$42,039.70	4.5	\$189,178.65
Total benefits for CRC screening			\$189,178.65
Total cost-benefit for CRC screening			\$32,926.33

CRC indicates colorectal cancer; FIT, fecal immunochemical test; GI, gastrointestinal.

^aAssumptions: All patients received a full colonoscopy instead of a sigmoidoscopy. Pathology costs represent the product of the average number of jars per patient (1.4) and total patients (24). All unit costs were based on 2017 Medicare payment rates. Anesthesia unit costs were calculated assuming a 45-minute/three units of time interval per unit. Complication costs were estimated using diagnosis-related groups and the Texas PricePoint tool. Direct initial CRC costs avoided are a median of six previous studies of initial direct medical costs for treating CRC. Three patients were excluded from the 100% follow-up due to assumed precluded health. All colonoscopy costs with any intervention were averaged. Units represent the number of patients applicable based on the results from the data analysis and applied rates from the literature review.

42 patients would have a colonoscopy without an intervention and 49 patients would receive a colonoscopy with an intervention. Further, whereas each of the 49 patients who received a colonoscopy with intervention would have a pathology, only 9.17 patients (2.09 dysplastic and 7.08 adenomatous patient equivalents) would receive the full cost avoidance benefit of screening. In this situation, total benefits through costs avoided increased from \$189,178 to \$385,363. Total annual benefits less costs were calculated to be over \$63,237 for the year in which the patients were screened.

In a follow-up sensitivity analysis, the rate of follow-up colonoscopies appears to be the main driver in costs avoided/savings instead of overall rate of follow-ups (*Figure 2*). Total

complication rates were not a major driver of cost; however, at the model's minimum follow-up and colonoscopy rates, the overall costs appear greater than the benefits.

DISCUSSION

This two-part evaluation of CRC screening in an integrated health system demonstrates that improving screening guideline adherence can increase CRC cost avoided and, therefore, total monetary benefit for population. We found that though 68.09% of patients received appropriate follow-up care, in terms of being communicated results and offered a colonoscopy, only 47.87% of all patients had a follow-up colonoscopy as recommended by current treatment

Table 4. Cost-benefit analysis of patient panel with full follow-up rate^a

Variable	Unit cost	Units	Total
Costs of CRC screenings			
FIT screening	\$21.82	94.00	(\$2051.08)
Diagnostic colonoscopy	\$322.64	42.00	(\$13,550.88)
Colonoscopy with intervention	\$357.41	49.00	(\$17,513.04)
Anesthesia for low intestine	\$198.41	91.00	(\$18,055.31)
Pathology	\$69.62	68.60	(\$4775.93)
Complication (perforation)	\$26,159.00	0.02	(\$452.29)
Complication (bleeding, hospitalization)	\$26,159.00	0.14	(\$3784.95)
Complication (bleeding, transfusion)	\$26,159.00	0.07	(\$1880.57)
Complication (diverticulitis, hospitalization)	\$19,029.00	0.02	(\$398.28)
Other GI complication (observation)	\$138.60	0.01	(\$1.14)
Angina or myocardial infarction	\$31,352.00	0.05	(\$1597.70)
Stroke or transient ischemic attack	\$53,452.00	0.03	(\$1605.16)
Total cost for CRC screenings			(\$65,666.32)
Costs of CRC			
Direct initial CRC costs (distant-stage CRC)	\$42,039.70	4.18	(\$175,632.52)
Direct initial CRC costs (local-stage CRC)	\$38,694.28	2.09	(\$80,828.04)
Total costs for CRC			(\$256,460.57)
Total costs			(\$322,126.88)
Benefits of CRC screenings			
Direct initial CRC costs avoided	\$42,039.70	9.17	\$385,363.92
Total benefits for CRC screenings			\$385,363.92
Total cost-benefit for CRC screenings			\$63,237.03

CRC indicates colorectal cancer; FIT, fecal immunochemical test; GI, gastrointestinal.

^aAssumptions: All patients received a full colonoscopy instead of a sigmoidoscopy. Pathology costs represent the product of the average number of jars per patient (1.4) and total patients (24). All unit costs were based on 2017 Medicare payment rates. Anesthesia unit costs were calculating assuming a 45-minute/three units of time interval per unit. Complication costs were estimated using diagnosis-related groups and the Texas PricePoint tool. Direct initial CRC costs avoided are a median of six previous studies of initial direct medical costs for treating CRC. Three patients were excluded from the 100% follow-up due to assumed precluded health. All colonoscopy costs with any intervention were averaged. Units represent the number of patients applicable based on the results from the data analysis and applied rates from the literature review.

guidelines. For the assessed population, this equated to a benefit of over \$189,178, less \$33,478 in screening and \$122,773 in two patients with distant and local CRC. Had CRC screening guidelines been followed appropriately, the net benefit would have exceeded \$63,237. Additionally, a population simulation of 1000 patients that examined the sensitivity of monetary benefits across follow-up rates resulted in total monetary benefit, demonstrating that as follow-up and colonoscopy rates improved, overall monetary benefit significantly improved, because costs appear largely fixed or stagnant. Said differently, benefits of improving screening far outweigh the costs and demonstrate the need to incentivize higher rates of follow-up and colonoscopies to avoid costs.

Though follow-up rates fall within the range cited in the literature and above the national average for 2016 performance results for accountable care organizations (ACOs; ACO #19, 61.52%) and merit-based incentive payment system benchmark averages (ACO #113/PPRNET18, 57.48%), these results are underwhelming, especially given the increasing incidence of CRC in younger populations, the increasing number of baby boomers retiring into Medicare, and more pressure from payers and health systems to improve follow-up. A recent analysis of a large integrated urban safety net system in North Texas had similar results, where 42.30% of its study cohort failed to undergo a colonoscopy 1 year after positive screening compared to our 52.13%.²³ In that study,

however, 57% of cases of failing to undergo a colonoscopy were attributable to patient failures, primarily patient refusal, compared to our 17% of patients who refused and 3% who were unable to undergo a colonoscopy because of poor health. The remaining 30% of cases that failed to receive appropriate follow-up colonoscopies were due to provider or system-level failures. This suggests an opportunity to improve adherence through improved outreach and patient and physician education. Addressing patient preferences, such as accuracy of the test versus frequency of testing, through shared patient-provider decision making may increase compliance.⁵⁰

To our knowledge, this is the first evaluation that utilizes a CBM from a population health perspective to explore the financial impact of CRC screening rates. Though there is a rich literature on patient-level benefits and cost-effectiveness studies of CRC screenings, no analysis has attempted to measure the potential monetary benefits to health system or production efficiency potential of appropriate screenings.^{13–15,38,51,52} Our results indicate that despite only 47% of patients receiving follow-up colonoscopies after abnormal FITs, the total benefit net of costs exceeded costs from complications or increased resources devoted to screening.

Several studies have already explored the relationship between new delivery models (ACOs, patient-centered medical homes, and integrated delivery systems) and cancer screenings.^{54–57} However, more policies, pilots, and evaluations of the aforementioned are necessary to refine new care and payment models where cost-avoided dollars could be accounted for vis-à-vis shared savings. Though population health screening rate quality measures are already in use by payers and ACOs, policymakers should consider more closely linking CRC screening rates with alternative payment models.^{48,49} One example would be using shared savings of avoided CRC costs as an incentive to improve compliance. This would involve shifting screening from a process measure to more of an outcome measure, because measures could be linked with incidence rates to ensure that incentive payments are appropriately rewarded. Through these alternative payment models, benefits could therefore be reallocated by ACOs and other community health providers, who take accountability in other areas like diabetes prevention, community interventions for asthma, and reductions in obesity rates.

A limitation to this study relates to external validity (generalizability), in that only charts within the system (limited by geography, hospital not-for-profit status) were selected. Results may be biased because random sampling was used instead of cluster sampling based on ordering physician; the authors did not investigate whether there was a relationship between follow-up rates and ordering physician. Moreover, the sample size was too small to perform formal statistical analysis. Patients who died were excluded due to the time frame of analysis. Additionally, complication rates were not collected, and estimates for the incidence rates and costs associated with each complication had to be estimated from previous literature using populations that may not exactly

match the population in this study. We could not find data on what percentage of precancerous lesions, if not removed, would eventually be discovered as local CRC versus distant CRC. Thus, we calculated that all of these would be discovered as distant CRC, although this is probably not the case. Although we did our best to stay true to appropriate estimations for hospital costs, many of the primary source estimations vary widely. Our analysis did not consider the cost-benefit scenario of uninsured or underinsured populations. This population is less likely to receive CRC screening, and any malignancies found tend to be in a later stage (distant CRC) compared to malignancies found in those with health insurance. However, many hospitals, physicians, and pharmaceutical companies provide a degree of charity care annually, and it would not be unreasonable to think that providing charity care for screening would be more cost-effective from a population health and integrated health system perspective. Finally, this investigation assumed that all lesions were removed through endoscopy, but larger lesions may need to be removed through colectomy. However, this is relatively uncommon compared to endoscopic removal and, given the small size used in this investigation, would not be likely to impact the financial outcome.

Colorectal cancer is a devastating, prevalent, and expensive disease, but appropriate screening can significantly reduce its incidence and mortality. Adherence to screening guidelines, however, remains suboptimal. Though the assessed rate of follow-up after abnormal FIT (68.09%) is consistent with that found at other institutions, there is room for improvement, especially given the likely increase in new incidence and mortality rate. Health systems, ACOs, and payers should work together to structure financial incentives in a way that rewards providers for improved outreach and adherence guidelines. Optimized CRC screening could translate to the allocation of health care dollars toward other diseases.

ORCID

Trace Heavener  <http://orcid.org/0000-0002-1407-8736>

Victoria Jaeger  <http://orcid.org/0000-0002-8583-3081>

James Sing  <http://orcid.org/0000-0001-5563-0104>

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