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Patient Factors that Affect Quality of Colonoscopy Preparation

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Abstract

Background & Aims—Optimal colonoscopy preparation requires patients to adhere to written instructions and be activated to complete the task. Among patients with chronic disease, health literacy and patient activation have been associated with outcome, but these factors have not been studied for colonoscopy. We examined the association between health literacy, patient activation, and quality of bowel preparation.

Methods—We analyzed outpatient colonoscopy results from 462 adults, 55–74 y old (mean 62±6 y), who previously completed extensive neurocognitive assessments as part of a prospective study (Health Literacy and Cognitive Function in Older Adults). We collected information on cecal intubation, polyp detection, bowel preparation quality, and histopathology.

Results—One third of the patients (n=134) had suboptimal quality of bowel preparation, 15% (n=62) had fair quality, and 17% (n=72) had poor quality. Limited health literacy was associated

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with a lower level of education ($P<.001$), diabetes ($P<.001$), and a higher number of chronic conditions ($P<.001$), but not quality of colonoscopy preparation. No baseline characteristics were associated with patient activation. In multivariable analysis, after adjusting for demographics and clinical characteristics, diabetes (odds ratio [OR], 2.93; 95% confidence interval [CI], 1.35–6.36) and patient activation (OR, 2.07; 95% CI, 1.27–3.40) were independent predictors of suboptimal bowel preparation quality, but limited health literacy was not (OR, 0.76; 95% CI, 0.44–1.31).

Conclusions—We investigated the relationship between health literacy, patient activation, and colonoscopy preparation quality. Lower patient activation was an independent predictor of suboptimal bowel preparation quality. Interventions to improve colonoscopy preparation quality should consider the importance of patient activation within their design.

Keywords

LitCog; procedure; predictors; endoscopy

INTRODUCTION

Colonoscopy is an effective screening tool for colorectal cancer and the only modality allowing for simultaneous polyp detection and removal.¹ Several studies have shown the benefit of screening colonoscopy with polypectomy at decreasing colorectal cancer mortality.^{2–4} The effectiveness of colonoscopy in colorectal cancer screening relies on sufficient rates of adenoma detection and is dependent on both the endoscopist's skill and the quality of bowel preparation.^{5–7} Multiple studies have shown that suboptimal bowel preparation quality is associated with missed adenomas, increased interval cancer rates, cost, procedure time and unnecessary repeat exams.^{8–12}

While multiple studies have evaluated the role of specific bowel purgatives and optimal dosing regimens (single vs. split dose), fewer have examined the patient's role in bowel preparation and colonoscopy quality.^{13,14} Several reports have linked lower socioeconomic status, lack of social support, limited English proficiency, failure to colonoscopy follow instructions, and medical regimen complexity, to worse bowel preparation quality.^{11, 15–17} Smith et al demonstrated that low health literacy was associated with poor interpretation of common colonoscopy instructions; however, no published reports have examined how health literacy relates to actual colonoscopy quality in clinical practice.¹⁸ Complementary to health literacy barriers, no published studies to date have examined the role of patient activation on colonoscopy quality or outcomes.

Health literacy and patient activation have both been linked to multiple healthcare outcomes. Health literacy is defined by the Institute of Medicine as “the degree to which individuals can obtain, process, and understand the basic health information and services they need to make appropriate health decisions”.¹⁹ Over the past two decades, multiple seminal reports have shown the association between low health literacy and increased hospitalizations, mortality, and cost in diverse patient populations.²⁰ Patient activation is defined as “an individual's knowledge, skill, and confidence for managing his/her own health and health care”.²¹ The Patient Activation Measure (PAM) is a validated scale developed by Hibbard and colleagues to measure this construct.²² Higher PAM scores are associated with multiple health behaviors and outcomes including higher medication adherence and use of preventive health services.²³ Both health literacy and patient activation may predict the knowledge, ability, and confidence to interpret and adhere to colonoscopy preparation instructions. As such, both are viable targets for intervention, although the nature of the clinical response would differ if the problem were with health literacy versus patient activation.

Given the limited prior research examining patient factors in colonoscopy quality, our objective was to investigate the relationship between health literacy, patient activation, and bowel preparation quality among a cohort of screening-age adults previously recruited for a National Institute of Aging study, titled Health Literacy and Cognition among Older Adults, referred to herein as 'LitCog' (R01 AG03611, PI:Wolf). We hypothesized that patients with low health literacy and low patient activation may have higher rates of suboptimal bowel preparation quality.

METHODS

Study sample

The study sample was obtained from the LitCog study which has been previously described in detail.²⁴ Briefly, from August of 2008 to October 2010, English-speaking adults ages 55 to 74 who received care at an academic general internal medicine practice or a federally qualified health center in Chicago were recruited to participate in structured, in-depth interviews. A total of 832 participants were recruited into the LitCog study, 614 of them were from the academic site with an electronic health record (EHR) with access to colonoscopy reports. Of the 614 individuals at the EHR-equipped site, 512 stated they had undergone a colonoscopy in the past; 466 of whom had colonoscopy reports available for review (either from the study site or from an outside facility). Four patients were excluded on the basis of having inpatient colonoscopies, leaving 462 patients as the study sample; 455 of these participants had complete health literacy and patient activation assessments.

Data Collection

Study participants underwent two, in-person structured interviews, 7–10 days apart. A trained research assistant administered a series of assessments that included basic demographics, socioeconomic status, self-reported chronic conditions, and standardized measures of health literacy and patient activation (described below in the measures section). The following colonoscopy outcomes were obtained from the EHR: colonoscopy indication (screening, surveillance, anemia, heme-positive stool, other), outcomes (polyp size, cecal intubation, polyp detection, bowel preparation quality), and histopathology. The colonoscopy performed closest to the day of the in-person interview was used in the analysis. We also noted whether or not the patient had a colonoscopy prior to the index colonoscopy (referred to as 'previous colonoscopy'). The protocol for this study was approved by Institutional Review Board at the study site.

Measures

Patient characteristics assessed for the LitCog study included: age, gender, race, education, smoking status, and total number of self-reported chronic conditions (hypertension, diabetes, coronary artery disease, congestive heart failure, bronchitis, asthma, emphysema, arthritis, cancer, and depression). The self-reported chronic conditions were assessed in prior work by Wolf and colleagues.²⁵

Health Literacy—Health literacy was assessed by the Test of Functional Health Literacy in Adults (TOFHLA), a commonly used measure of literacy in healthcare research.²⁶ The TOFHLA is based on the use of materials patients likely encounter in healthcare and tests both literacy and numeracy.²⁶ The TOFHLA is scored on a scale from 0–100, a score of 75–100 indicates adequate literacy and <75 indicates limited literacy.²⁶

Patient Activation—Patient activation was evaluated with the shortened 13 item version of the original patient activation measure (PAM). The PAM-13 includes items that assess patient-reported knowledge, skills and confidence for self-management of chronic disease.²²

The scale categorizes individuals as being in one of four stages of activation. At level 1, patients do not possess the skills or knowledge to play an active role in managing their health, while at level 4, they have adopted many of the necessary behaviors to support their health, but may be unable to maintain them under stress.²¹ PAM scores were defined as low if participants scored at levels 1–3 and high if they scored at level 4.

Colonoscopy Quality and Outcomes—Colonoscopy quality indicators such as cecal intubation rate (CIR), polyp detection rate (PDR), adenoma detection rate (ADR), and bowel preparation quality were abstracted from the electronic health record. PDR was defined as the proportion of individuals found to have at least one polyp, whereas, ADR was the proportion of individuals found to have at least one adenomatous polyp.²⁷ A 6 category scale (excellent, good, adequate, fair, poor, inadequate) was initially used to define bowel preparation quality based on endoscopist documentation. For the main analysis, the categories were combined into a 2 category scale (optimal=excellent, good; suboptimal=adequate, fair, poor, inadequate). Most colonoscopy reports (N=395, 83%) were dictated by the individual endoscopist; for the remainder (N=77, 17%), the preparation quality was generated by an electronic program with pre-populated fields. A medical record review was performed to examine whether patients had a repeat colonoscopy (either at this institution or an outside institution) in less than 3 years due to suboptimal preparation quality.

Analysis Plan

Data were summarized by calculating descriptive statistics for demographic variables and colonoscopy characteristics. The sample was initially stratified by the predictors of interest; health literacy level and PAM scores. Bivariate analyses were completed, using Chi-squared tests for binary variables and t-tests for continuous variables, in order to compare sample characteristics, and colonoscopy outcomes (CIR, ADR, and bowel preparation quality). Spearman's correlation coefficient was used to examine the association between health literacy and PAM score.

We conducted sensitivity analyses for the various categories of bowel preparation quality to examine whether changing the categorization had a significant effect on outcomes. For bowel preparation quality, in addition to the 2 category scale (suboptimal vs. optimal), we examined a 3 category scale: excellent/good vs. adequate/fair vs. inadequate/poor. We also performed the analyses grouping “adequate” preparation into the “optimal category”. We performed additional sensitivity analyses using various dichotomous combinations for the 4 levels of PAM.

Based on the similar results of the sensitivity analyses, we chose to use a logistic regression model using the 2 category scale of bowel preparation quality (suboptimal vs. optimal) and the categorization of PAM as level 4 vs. all others, for ease of interpretation. Covariates such as baseline demographics and literacy were chosen by convention while additional covariates were chosen for p values <0.10 in bivariate analyses. The final model included basic demographic information, diabetes, number of chronic conditions, PAM score, and presence of previous colonoscopy. Model goodness of fit was tested with the Hosmer-Lemeshow statistic. All analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Table 1 provides the baseline demographics of the study sample by health literacy and PAM score. The mean age of participants undergoing colonoscopy was 61.6 (SD =6.2), with a mean interval of 2.7 (SD=2.3) years between the colonoscopy and the in-person interview.

The majority of patients were non-Hispanic White, female, and college graduates. There was a significant association between health literacy and education ($P<.01$); patients with limited health literacy were more likely to have diabetes ($P<.01$), and a higher number of chronic conditions ($P<.01$). No significant differences in baseline characteristics were observed among participants by PAM score.

Bowel preparation quality was reported in 412 of 462 colonoscopies (89.2%, Table 2). Preparation quality was suboptimal in one third of cases; 15.5% ($N=64$) were fair ($N=42$) or adequate ($N=22$), and 17.0% ($N=70$) were poor ($N=57$) or inadequate ($N=13$). Participants with low PAM scores were significantly more likely to have suboptimal bowel preparation quality as compared to patients with high PAM scores. There were no significant differences in CIR, ADR, bowel preparation quality, or repeat colonoscopy in less than 3 years due to suboptimal preparation by health literacy. Patients who had undergone a previous colonoscopy were slightly more likely to have suboptimal bowel preparation quality (38% vs. 29%), however, the relationship was not statistically significant ($P=.06$).

In unadjusted analyses (Table 3), diabetes, number of chronic conditions and low PAM score were significantly associated with suboptimal bowel preparation quality. After controlling for age, gender, race, education, number of chronic conditions, PAM score, health literacy, and previous colonoscopy, diabetes and patient activation remained significantly associated with suboptimal bowel preparation quality. There were no interactions found among independent variables and covariates, and none of the patient factors significantly predicted CIR, PDR, or ADR. Bowel preparation quality was not associated with procedure indication, ADR, ability to detect polyps less than 10 mm, or right-sided polyps. The correlation between health literacy and PAM score was low (Spearman's $\rho=.14$).

In sensitivity analyses, when bowel preparation quality was grouped into 3 categories (excellent/good vs. adequate/fair vs. inadequate/poor), the PAM was still significantly associated with bowel preparation quality ($P<.01$). When we re-categorized "adequate" preparation quality into the "excellent/good" category, the association did not reach statistical significance ($P=.06$). The presence of diabetes was still significantly associated with bowel preparation quality using the 3 category scale ($P=.02$), while health literacy was not ($P=.81$). When two additional combinations of PAM categories were used, no changes were observed in the relationship between PAM and bowel preparation quality compared to primary analyses. Varying the categories of bowel preparation quality and PAM did not change the associations with other colonoscopy outcomes (CIR, PDR, ADR, or repeat colonoscopy in <3 years).

DISCUSSION

This study is the first to our knowledge to examine the effects of health literacy and patient activation on bowel preparation quality for colonoscopy. In this group of adults over 55 years of age, we found suboptimal bowel preparation quality in about a third of individuals undergoing outpatient colonoscopy; a proportion consistent with prior studies.^{8,9} We have also confirmed that presence of diabetes as an independent risk factor for suboptimal bowel preparation quality as previously reported.^{16,17,28,29} We have newly demonstrated that low patient activation independently predicted suboptimal bowel preparation quality while health literacy did not. Not surprisingly, health literacy and patient activation were not correlated in our sample. While both health literacy (a measure of cognitive skill) and patient activation (a measure of patient engagement) have previously been found to predict health behavior, these two measures are complementary and each captures a unique, often unmeasured patient trait.^{23,24}

The few previous investigations of patient factors in colonoscopy preparation have been limited.^{15,16} The large sample size and detailed cognitive and socio-demographic information from the LitCog study cohort presented a unique opportunity for an in-depth examination of potentially modifiable, individual risk factors in colonoscopy preparation. While health literacy was not associated with bowel preparation quality, the proportion of patients with limited literacy was relatively low and the relationship should be verified among a more diverse population. The association between patient activation and bowel preparation quality suggests that the level of patient engagement in personal health is an important factor in colonoscopy preparation. This finding is not surprising given that patients with higher activation are more engaged in healthy behaviors, more likely to seek health information and ask questions, and more likely to undergo age-appropriate cancer screening.^{23,30} Low activation has also been linked to higher healthcare costs.³⁰ Recently, several large health plans have begun to adopt the PAM as an additional screening tool upon enrollment to identify individuals who may require additional counseling and support.^{23,30} More evidence is needed to prospectively track PAM scores over time, link PAM to longitudinal outcomes, and examine the cost-effectiveness of measuring PAM.

Our results have several important implications for future research and clinical practice. Previous interventions to improve bowel preparation quality through enhanced educational sessions or simplified print materials have yielded mixed results.^{32–35} Our findings suggest that any efforts that focus on simply improving education or the readability of colonoscopy instructions may not be responding to the root cause of poor preparation quality if individuals are not properly activated to complete this task. Rather, steps should be taken to identify those who may accept a colonoscopy recommendation, but may not be motivated to fully prepare for the procedure. Those with ‘low activation’ could perhaps be clinically screened for, and interventions may include education but more importantly involve brief counseling. The latter could involve a review of the importance of proper preparation, benefits of colonoscopy as well as additional limitations and risks if the endoscopist cannot adequately perform the procedure due to poor quality preparation. A recent trial demonstrated that a telephone-administered education program prior to colonoscopy improved bowel preparation quality and polyp detection; more studies should verify whether patients with low activation may benefit from this type of intervention.³⁶

While assessments such as the PAM might be considered as a clinical screening tool due to its brevity, other ways to identify potentially at-risk patients might be via electronic health records by reviewing recent adherence to other clinical preventive services or achieving clinical goals for chronic disease outcomes. Further studies should be conducted to develop and validate new, abbreviated measures of patient activation that can be used in routine patient care.

This study has several limitations. This was a cross-sectional study where causation cannot be established. The study sample consisted predominantly of non-Hispanic white participants and females with a high level of education; the results may, therefore, be less generalizable to other populations undergoing colonoscopy. While health literacy was not a determinant of bowel preparation quality, we may have been limited in our ability to detect a difference given the small proportion of patients with limited literacy in our study sample. The overall rates of CIR and ADR were high and PAM was not associated with these outcomes. Despite these limitations, there was a significant correlation between PAM and suboptimal preparation—an important quality indicator which has been shown to increase procedure time and cost.¹⁰ We recommend that similar prospective studies be performed among a more socioeconomically diverse community sample with greater variability across health literacy and PAM scores.

The average time interval between literacy, patient activation assessments and colonoscopy was about 2.5 years; we are unable to fully account for any changes in health literacy and patient activation over time. However, among a subset of patients who underwent a colonoscopy within 1 year of the study interview (N=397, 85%), a similar trend was noted (44% of patients with suboptimal preparation had low PAM scores compared to 31% with high PAM scores, $p=.06$). The assessment of bowel preparation quality was not standardized, potentially resulting in measurement bias and overestimation of suboptimal preparation quality, however, in sensitivity analyses, the association between PAM and bowel preparation quality remained statistically significant. We may have been limited in our ability to detect all patients with repeat colonoscopy in less than 3 years or with prior colonoscopy experience if they were performed at another institution. We did not assess narcotic use or baseline constipation, which may affect preparation quality. Another important unmeasured component was the type of instructions the patients received prior to the procedure.

In conclusion, our study was the first to perform a detailed examination of the relationship between patient factors and bowel preparation quality for colonoscopy. Low patient activation was a significant independent predictor of colonoscopy bowel preparation quality, while health literacy was not. Future prospective studies among a more diverse sample are needed to confirm this relationship. Interventions to improve colonoscopy quality should consider the importance of patient activation within their design.

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Abbreviations

ADR	adenoma detection rate
CIR	cecal intubation rate
PAM	patient activation measure
TOFHLA	test of functional health literacy in adults

REFERENCES

1. Levin B, Lieberman DA, McFarland B, et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. *Gastroenterology*. 2008; 134:1570–1595. [PubMed: 18384785]
2. Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. *N Engl J Med*. 2012; 366:687–696. [PubMed: 22356322]

3. Winawer SJ, Zauber AG, Ho MN, et al. Prevention of colorectal cancer by colonoscopic polypectomy. The National Polyp Study Workgroup. *N Engl J Med.* 1993; 329:1977–1981. [PubMed: 8247072]
4. Muller AD, Sonnenberg A. Protection by endoscopy against death from colorectal cancer. A case-control study among veterans. *Arch Intern Med.* 1995; 155:1741–1748. [PubMed: 7654107]
5. Quintero E, Castells A, Bujanda L, et al. Colonoscopy versus fecal immunochemical testing in colorectal-cancer screening. *N Engl J Med.* 2012; 366:697–706. [PubMed: 22356323]
6. Kaminski MF, Regula J, Kraszewska E, et al. Quality indicators for colonoscopy and the risk of interval cancer. *N Engl J Med.* 2010; 362:1795–1803. [PubMed: 20463339]
7. Soetikno RM, Kaltenbach T, Rouse RV, et al. Prevalence of nonpolypoid (flat and depressed) colorectal neoplasms in asymptomatic and symptomatic adults. *JAMA.* 2008; 299:1027–1035. [PubMed: 18319413]
8. Lebwohl B, Kastrinos F, Glick M, Rosenbaum AJ, Wang T, Neugut AI. The impact of suboptimal bowel preparation on adenoma miss rates and the factors associated with early repeat colonoscopy. *Gastrointest Endosc.* 2011; 73:1207–1214. [PubMed: 21481857]
9. Harewood GC, Sharma VK, de Garmo P. Impact of colonoscopy preparation quality on detection of suspected colonic neoplasia. *Gastrointest Endosc.* 2003; 58:76–79. [PubMed: 12838225]
10. Rex DK, Imperiale TF, Latinovich DR, Bratcher LL. Impact of bowel preparation on efficiency and cost of colonoscopy. *Am J Gastroenterol.* 2002; 97:1696–1700. [PubMed: 12135020]
11. Froehlich F, Wietlisbach V, Gonvers JJ, Burnand B, Vader JP. Impact of colonic cleansing on quality and diagnostic yield of colonoscopy: the European Panel of Appropriateness of Gastrointestinal Endoscopy European multicenter study. *Gastrointest Endosc.* 2005; 61:378–384. [PubMed: 15758907]
12. Larsen M, Hills N, Terdiman J. The impact of the quality of colon preparation on follow-up colonoscopy recommendations. *Am J Gastroenterol.* 2011; 106:2058–2062. [PubMed: 22138933]
13. Enestvedt BK, Tofani C, Laine LA, Tierney A, Fennerty MB. 4-Liter split-dose polyethylene glycol is superior to other bowel preparations, based on systematic review and meta-analysis. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association.* 2012; 10:1225–1231. [PubMed: 22940741]
14. Juluri R, Eckert G, Imperiale TF. Meta-analysis: randomized controlled trials of 4-L polyethylene glycol and sodium phosphate solution as bowel preparation for colonoscopy. *Aliment Pharmacol Ther.* 2010; 32:171–181. [PubMed: 20384609]
15. Ness RM, Manam R, Hoen H, Chalasani N. Predictors of inadequate bowel preparation for colonoscopy. *Am J Gastroenterol.* 2001; 96:1797–1802. [PubMed: 11419832]
16. Nguyen DL, Wieland M. Risk factors predictive of poor quality preparation during average risk colonoscopy screening: the importance of health literacy. *Journal of gastrointestinal and liver diseases : JGLD.* 2010; 19:369–372. [PubMed: 21188326]
17. Chung YW, Han DS, Park KH, et al. Patient factors predictive of inadequate bowel preparation using polyethylene glycol: a prospective study in Korea. *Journal of clinical gastroenterology.* 2009; 43:448–452. [PubMed: 18978506]
18. Smith SG, von Wagner C, McGregor LM, et al. The influence of health literacy on comprehension of a colonoscopy preparation information leaflet. *Diseases of the colon and rectum.* 2012; 55:1074–1080. [PubMed: 22965407]
19. Institute of Medicine. Measures of health literacy: Workshop summary. Washington, DC: The National Academies Press; 2009.
20. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med.* 2011; 155:97–107. [PubMed: 21768583]
21. Fowles JB, Terry P, Xi M, Hibbard J, Bloom CT, Harvey L. Measuring self-management of patients' and employees' health: further validation of the Patient Activation Measure (PAM) based on its relation to employee characteristics. *Patient education and counseling.* 2009; 77:116–122. [PubMed: 19356881]
22. Hibbard JH, Mahoney ER, Stockard J, Tusler M. Development and testing of a short form of the patient activation measure. *Health services research.* 2005; 40:1918–1990. [PubMed: 16336556]

23. Hibbard JH, Greene J. What the evidence shows about patient activation: better health outcomes and care experiences; fewer data on costs. *Health affairs*. 2013; 32:207–214. [PubMed: 23381511]
24. Wolf MS, Curtis LM, Wilson EA, et al. Literacy, cognitive function, and health: results of the LitCog study. *J Gen Intern Med*. 2012; 27:1300–1307. [PubMed: 22566171]
25. Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. *Arch Intern Med*. 2005; 165:1946–1952. [PubMed: 16186463]
26. Parker RM, Baker DW, Williams MV, Nurss JR. The test of functional health literacy in adults: a new instrument for measuring patients' literacy skills. *Journal of General Internal Medicine*. 1995; 10:537–541. [PubMed: 8576769]
27. Rex DK, Petrini JL, Baron TH, et al. Quality indicators for colonoscopy. *Am J Gastroenterol*. 2006; 101:873–885. [PubMed: 16635231]
28. Chorev N, Chadad B, Segal N, et al. Preparation for colonoscopy in hospitalized patients. *Dig Dis Sci*. 2007; 52:835–839. [PubMed: 17253131]
29. Taylor C, Schubert ML. Decreased efficacy of polyethylene glycol lavage solution (golytely) in the preparation of diabetic patients for outpatient colonoscopy: a prospective and blinded study. *Am J Gastroenterol*. 2001; 96:710–714. [PubMed: 11280539]
30. Greene J, Hibbard JH. Why does patient activation matter? An examination of the relationships between patient activation and health-related outcomes. *J Gen Intern Med*. 2012; 27:520–526. [PubMed: 22127797]
31. Hibbard JH, Greene J, Overton V. Patients with lower activation associated with higher costs; delivery systems should know their patients' 'scores'. *Health affairs*. 2013; 32:216–222. [PubMed: 23381513]
32. Calderwood AH, Lai EJ, Fix OK, Jacobson BC. An endoscopist-blinded, randomized, controlled trial of a simple visual aid to improve bowel preparation for screening colonoscopy. *Gastrointest Endosc*. 2011; 73:307–314. [PubMed: 21168840]
33. Spiegel BM, Talley J, Shekelle P, et al. Development and validation of a novel patient educational booklet to enhance colonoscopy preparation. *Am J Gastroenterol*. 2011; 106:875–883. [PubMed: 21483463]
34. Tae JW, Lee JC, Hong SJ, et al. Impact of patient education with cartoon visual aids on the quality of bowel preparation for colonoscopy. *Gastrointest Endosc*. 2012; 76:804–811. [PubMed: 22840295]
35. Modi C, Depasquale JR, Digiacomo WS, et al. Impact of patient education on quality of bowel preparation in outpatient colonoscopies. *Quality in primary care*. 2009; 17:397–404.
36. Liu X, Luo H, Zhang L, et al. Telephone-based re-education on the day before colonoscopy improves the quality of bowel preparation and the polyp detection rate: a prospective, colonoscopist-blinded, randomised, controlled study. *Gut*. 2013

Table 1

Baseline Patient Demographics and Characteristics by Health Literacy and PAM

Variable	All Participants (N=462)	Health Literacy (N=455)		P value	PAM Score (N=462)		P value
		Limited (N=76)	Adequate (N=379)		Low (N=116)	High (N=346)	
Age, mean (SD)	61.6 (6.2)	63.6 (6.7)	61.1 (6.0)	<0.01	61.6 (6.3)	61.3 (5.9)	0.59
Gender, n (%)							
Male	138 (29.9)	20 (26.3)	118 (31.1)	0.40	31 (26.7)	107 (30.9)	0.39
Female	324 (70.1)	56 (73.7)	261 (68.9)		85 (73.3)	239 (69.1)	
Race, n (%)							
White	298 (65.1)	19 (25.3)	274 (72.9)	<0.01	71 (62.3)	227 (65.9)	0.89
African American	125 (27.3)	44 (58.7)	79 (21.0)		34 (29.8)	91 (26.5)	
Latino	13 (2.8)	6 (8.0)	7 (1.9)		3 (2.6)	10 (2.9)	
Other	22 (4.8)	6 (8.0)	16 (4.2)		6 (5.3)	16 (4.7)	
Education, n (%)							
High School or Less	77 (16.7)	37 (48.7)	40 (10.6)	<0.01	21 (18.1)	56 (16.2)	0.89
Some College	90 (19.5)	22 (28.9)	65 (17.1)		22 (19.0)	68 (19.6)	
College Graduate	295 (63.8)	17 (22.4)	274 (72.3)		73 (62.9)	222 (64.2)	
Diabetes, n (%)	48 (10.4)	17 (22.4)	31 (8.22)	<0.01	14 (12.1)	34 (9.9)	0.51
Chronic Conditions, mean (SD)	1.6 (1.2)	2.2 (1.3)	1.5 (1.2)	<0.01	1.6 (1.1)	1.8 (1.4)	0.10
Previous Colonoscopy, n (%)	179 (38.7)	37 (48.6)	142 (37.5)	0.08	39 (33.6)	140 (30.3)	0.57

PAM- patient activation measure

Table 2
Colonoscopy Characteristics and Quality Indicators by Health Literacy and PAM

Variable	All Participants (N=462) n, %	Health Literacy (N=455)		P value	PAM Score (N=462)		P value
		Limited (N=76) n, %	Adequate (N=379) n, %		Low (N=116) n, %	High (N=346) n, %	
Indication							
Screening	293 (65.9)	45 (60.0)	245 (67.7)	0.41	79 (69.9)	214 (64.6)	0.20
Surveillance	103 (23.2)	22 (29.3)	80 (22.1)		20 (17.7)	83 (25.1)	
Anemia, Heme+ stool, Bleeding	34 (7.7)	7 (9.3)	26 (7.2)		8 (7.1)	26 (7.9)	
Other	14 (3.2)	1 (1.3)	11 (3.0)		6 (5.3)	8 (2.4)	
Cecal intubation rate	448 (97.6)	72 (96.0)	369 (97.9)	0.34	113 (98.3)	335 (97.4)	0.59
Polyp detection rate	151 (32.9)	28 (37.3)	122 (32.4)	0.40	42 (36.5)	109 (31.7)	0.34
Adenoma detection rate	124 (26.8)	22 (29.0)	101 (26.7)	0.68	32 (27.6)	92 (26.6)	0.83
Bowel Preparation Quality							
Optimal [Excellent/Good]	278 (67.5)	42 (62.7)	233 (68.9)	0.32	59 (56.2)	219 (71.3)	<0.01
*Suboptimal [Adequate Fair/Poor/Inadequate]	134 (32.5)	25 (37.3)	105 (31.1)		46 (43.8)	88 (28.7)	
Repeat colonoscopy < 3 yrs	38 (8.2)	9 (11.8)	27 (7.1)	0.16	9 (7.8)	29 (8.4)	0.83

PAM-patient activation measure

* bowel preparation quality not reported in 50 cases

Table 3
Health Literacy, Patient Activation, and Suboptimal Bowel Preparation Quality: Multivariable Analysis

Variable	Unadjusted OR's		Adjusted OR's	
	OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age at Colonoscopy				
	1.01 (0.98, 1.04)	0.59	1.00 (0.97, 1.04)	0.87
Gender				
Female	REF		REF	
Male	0.88 (0.55, 1.39)	0.58	0.86 (0.52, 1.43)	0.61
Race				
White	REF		REF	
Black	1.49 (0.94, 2.37)	0.09	1.22 (0.70, 2.11)	0.48
Latino	1.20 (0.35, 4.09)	0.76	0.92 (0.41, 3.52)	0.91
Other	2.13 (0.79, 5.71)	0.13	1.79 (0.57, 5.59)	0.32
Education				
College Graduate	REF		REF	
Some College	0.92 (0.53, 1.58)	0.76	0.82 (0.44, 1.54)	0.55
High School	1.47 (0.85, 2.56)	0.17	1.40 (0.72, 2.72)	0.32
Diabetes				
No	REF		REF	
Yes	2.79 (1.48, 5.27)	<0.01	2.45 (1.14, 5.25)	0.02
Number of Chronic Conditions	1.21 (1.02, 1.43)	0.03	1.02 (0.83, 1.25)	0.87
PAM Score				
High PAM Score	REF		REF	
Low PAM Score	1.94 (1.23, 3.07)	<0.01	2.12 (1.30, 3.45)	<0.01
Health Literacy				
Adequate Health Literacy	REF		REF	
Limited Health Literacy	0.76 (0.44, 1.31)	0.32	0.76 (0.38, 1.52)	0.44
Previous Colonoscopy				
No	REF		REF	
Yes	1.49 (0.98, 2.27)	0.06	1.52 (0.95, 2.46)	0.08

PAM-patient activation measure
OR- odds ratio