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Association of Health Literacy With Postoperative Outcomes in Patients Undergoing Major Abdominal Surgery

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Invited Commentary

IMPORTANCE Low health literacy is known to adversely affect health outcomes in patients with chronic medical conditions. To our knowledge, the association of health literacy with postoperative outcomes has not been studied in-depth in a surgical patient population.

OBJECTIVE To evaluate the association of health literacy with postoperative outcomes in patients undergoing major abdominal surgery.

DESIGN, SETTING, AND PARTICIPANTS From November 2010 to December 2013, 1239 patients who were undergoing elective gastric, colorectal, hepatic, and pancreatic resections for both benign and malignant disease at a single academic institution were retrospectively reviewed. Patient demographics, education, insurance status, procedure type, American Society of Anesthesiologists status, Charlson comorbidity index, and postoperative outcomes, including length of stay, emergency department visits, and hospital readmissions, were reviewed from electronic medical records. Health literacy levels were assessed using the Brief Health Literacy Screen, a validated tool that was administered by nursing staff members on hospital admission. Multivariate analysis was used to determine the association of health literacy levels on postoperative outcomes, controlling for patient demographics and clinical characteristics.

MAIN OUTCOMES AND MEASURES The association of health literacy with postoperative 30-day emergency department visits, 90-day hospital readmissions, and index hospitalization length of stay.

RESULTS Of the 1239 patients who participated in this study, 624 (50.4%) were women, 1083 (87.4%) where white, 96 (7.7%) were black, and 60 (4.8%) were of other race/ethnicity. The mean (SD) Brief Health Literacy Screen score was 12.9 (SD, 2.75; range, 3-15) and the median educational attainment was 13.0 years. Patients with lower health literacy levels had a longer length of stay in unadjusted (95% CI, 0.95-0.99; *P* = .004) and adjusted (95% CI, 0.03-0.26; *P* = .02) analyses. However, lower health literacy was not significantly associated with increased rates of 30-day emergency department visits or 90-day hospital readmissions.

CONCLUSIONS AND RELEVANCE Lower health literacy levels are independently associated with longer index hospitalization lengths of stay for patients who are undergoing major abdominal surgery. The role of health literacy needs to be further evaluated within surgical practices to improve health care outcomes and use.

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Health literacy (HL) is defined as an individual's ability to obtain, process, and understand health information to make informed decisions and function effectively in the health care environment.[1-3] The Institute of Medicine and the US Department of Health and Human Services have identified HL as a priority area for disease prevention and health promotion. In 2003, the National Assessment of Adult Literacy, through the Institute of Education Sciences, estimated that 36% of the US population was classified as having "basic" (22%) or "below basic" (14%) HL levels, corresponding to approximately 117 million people today.[2-4] Conversely, only 12% of the US population is considered to have a "proficient" HL level.[3]

Demographic characteristics including sex, race/ethnicity, primary language, age, level of highest education, and socioeconomic status are associated with HL.[3] Additionally, a low HL level is known to negatively influence medical management and lead to poorer health outcomes in several populations with chronic diseases, including hypertension,[5] asthma,[6,7] diabetes,[5,8,9] congestive heart failure,[10-13] and end-stage renal disease.[14,15] Low HL has been associated with higher all-cause mortality rates in elderly populations.[2,11] Given the importance of HL with self-management following discharge, low HL has also been shown to be associated with a higher incidence of unplanned readmissions[16,17] and an increased rate of acute care and emergency department (ED) visits.[18]

With the known associations between HL and outcomes for patients with chronic medical conditions, there are a paucity of data within the surgical literature that evaluate the role of HL on postoperative outcomes. In one observational study of patients undergoing general surgery, Chew et al[19] demonstrated that 12% of patients in an ambulatory surgery practice in a Veteran Affairs population were found to have low HL levels, which correlates with estimates among the general population.[19] Additionally, low HL, within a population of patients who were undergoing a radical cystectomy, was found to be predictive of developing minor postoperative complications.[20] Based on estimates from prior population studies using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, there are an estimated 18 970 annual colorectal, pancreatic, and hepatic resections for malignant processes.[21,22] Given the complexity of these procedures, the effect of HL is unknown in this population.

During the perioperative period there are several opportunities for low HL levels to adversely affect patient care. Low HL is known to negatively affect a patient's understanding of perioperative instructions,[19] general consent forms,[23,24] prescription labels,[2,25] and appointment schedules.[2] Considering these data, the surgical population is susceptible to poor health outcomes; thus, the relationship between HL and surgical outcomes needs to be further assessed.

The aim of this study was to evaluate the influence of HL, using the Brief Health Literacy Screen (BHLS), on postoperative outcomes, specifically index hospitalization length of stay (LOS), postoperative 30-day ED visits, and 90-day hospital readmission rates among patients who were undergoing major, elective abdominal surgical procedures.

Key Points

Question What is the association of health literacy with postoperative outcomes in patients undergoing major inpatient abdominal surgery?

Findings In a this study of 1239 patients who were undergoing major abdominal surgery, lower health literacy levels were independently associated with an increased index hospitalization length of stay. However, low health literacy was not associated with increased emergency department visits or hospital readmissions following discharge.

Meaning Identifying patients with low health literacy and addressing their specific needs may facilitate timely hospital discharges and decreased lengths of stay.

Methods

Setting and Patient Population

We evaluated 1239 English-speaking patients from November 2010 to December 2013 who had undergone elective gastric, colorectal, hepatic, or pancreatic resections in a single tertiary referral, academic teaching hospital. Procedures included open or laparoscopic approaches. Resections for both benign and malignant processes were included. In 2010, the BHLS was implemented institutionally, for all admissions, at the authors' home institution,[26] and eligible patients had a BHLS score that was documented within the electronic medical record. Patients were 18 years or older. The institutional review board at Vanderbilt University approved this study and waived informed consent for record review.

Measuring Health Literacy

Accurately measuring and quantifying HL with administrative ease is an important component of patient assessment. The BHLS is a validated screening tool that is administered by nursing staff members on hospital admission to assess HL levels.[27-29] The BHLS has been validated across several patient populations[14,30,31] and has been implemented institutionally as the primary HL assessment tool in both the inpatient and outpatient settings.[26] Administration takes approximately 1 to 2 minutes, consists of 3 questions, and the results are entered directly into the electronic medical record. Nursing personnel administered the BHLS to patients on admission to the hospital along with other intake assessment forms. The BHLS questions are as follows: (1) How confident are you in filling out medical forms by yourself? (2) How often do you have someone help you read hospital materials? and (3) How often do you have problems learning about your medical condition because of difficulty understanding written information? Answers are scored on a 5-point Likert response scale. Responses are tallied for a possible score of 3 to 15 points, with higher numbers representing higher HL levels. The scores were categorized into quartiles as low (3-8), intermediate (9-11), intermediate-high (12-14), or high (15) HL for descriptive and comparative purposes. The BHLS score was treated as a

Table 1. Patient Demographics and Postoperative Outcomes Stratified by Basic Health Literacy Screen Score

Characteristic	BHLS Score, No. (%) Low (3-8) (n = 86 [6.9%])	Intermediate (9-11) (n = 244 [19.7%])	Intermediate-High (12-14) (n = 278 [22.4%])	High (15) (n = 631 [50.9%])	Total (n = 1239)	*P* Value
Age, median (IQR), y	65.0 (52.0-67.0)	59.0 (49.0-69.0)	58.5 (47.0-67.0)	54.0 (42.0-64.0)	57.0 (46.0-67.0)	<.001[a]
Sex						
Male	47 (7.3)	129 (21.0)	144 (23.4)	295 (48.0)	615 (49.6)	.21[b]
Female	39 (6.3)	115 (18.4)	134 (21.5)	336 (53.8)	624 (50.4)	
Race/ethnicity						.
White	68 (6.3)	211 (19.5)	245 (22.6)	559 (51.6)	1083 (87.4)	.31[b]
Black	11 (11.5)	19 (19.8)	22 (22.9)	44 (45.8)	96 (7.7)	
Other	7 (11.7)	14 (28.3)	11 (18.3)	28 (46.7)	60 (4.8)	
Education, median (IQR), y	12.0 (11.0-13.5)	12.0 (12.0-14.0)	13.0 (12.0-15.0)	14.0 (12.0-16.0)	13.0 (12.0-16.0)	<.001[a]
Charlson comorbidity index, median (IQR)	2.0 (1.0-4.3)	2.0 (0.0-4.0)	2.0 (0.0-6.0)	2.0 (0.0-4.0)	2.0 (0.0-4.0)	.11[a]
Procedure type						
Gastric resection	6 (11.8)	18 (35.3)	8 (15.7)	19 (37.3)	51 (4.1)	.002[b]
Pancreatic resection	17 (7.9)	40 (18.5)	51 (23.6)	108 (50.0)	216 (17.4)	
Hepatic resection	19 (8.0)	52 (21.9)	68 (28.7)	98 (41.4)	237 (19.1)	
Colorectal resection	44 (6.0)	134 (18.2)	151 (20.5)	406 (55.2)	735 (59.3)	
ASA class						
1	0 (0.0)	1 (10.0)	3 (30.0)	6 (60.0)	10 (0.8)	<.001[b]
2	17 (4.1)	65 (15.5)	86 (20.5)	251 (59.9)	419 (33.8)	
3	63 (8.2)	169 (21.9)	179 (23.2)	361 (46.8)	772 (62.3)	
4	6 (15.8)	9 (23.7)	10 (26.3)	13 (34.2)	38 (3.1)	
Length of stay, median (IQR), d	6.0 (4.0-10.0)	6.0 (4.0-8.8)	6.0 (4.0-8.0)	5.0 (4.0-7.0)	5.0 (4.0-8.0)	.004[a]
ICU length of stay, median (IQR), d	0.0 (0.0-0.3)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	.01[a]
Complications, in-house	12 (6.7)	38 (21.2)	46 (25.7)	83 (46.4)	179 (14.4)	.55[b]
ED visit within 30 d	15 (8.2)	31 (17.0)	45 (24.7)	91 (50.0)	182 (14.7)	.61[b]
Readmission within 90 d	22 (8.3)	50 (18.9)	62 (23.4)	131 (49.4)	265 (21.4)	.73[b]

Abbreviations: ASA, American Society of Anesthesiologist; BHLS, Basic Health Literacy Screen; ED, emergency department; ICU, intensive care unit; IQR, interquartile range.

[a] Kruskal-Wallis test.

[b] χ^2 test.

continuous variable in the multivariate analyses, as intended by the original authors.[27,28]

Statistical and Patient Analysis

Patient demographics, highest education level attained, insurance status, procedure type (colorectal, gastric, hepatic, or pancreatic resection), American Society of Anesthesiologists (ASA) status, Charlson comorbidity index,[32] major postoperative complications during index hospitalization (as defined by ACS-NSQIP),[33] index hospitalization LOS, 30-day ED visits, and 90-day hospital readmissions from the date of discharge were reviewed from the electronic medical record. Highest level of education (years) is routinely collected by nursing personnel, just as the BHLS is, as part of the intake documentation process during admission at our institution. Length of stay was defined as the number of days from surgery to the date of discharge. Hospital readmission was defined as any admission, for any reason, within 90 days following a discharge from index hospitalization.

A bivariate analysis was performed using the Kruskal-Wallis test for nonnormally distributed continuous variables, and a χ^2 analysis was used for categorical variable comparisons. A multivariate analysis that used logistic and linear regression modeling was used to determine the association of collected variables on postoperative outcomes. Specifically, we analyzed age, sex, race/ethnicity, BHLS score, the highest level of completed education (years), Charlson comorbidity index, ASA class, procedure type, postoperative complications, and insurance status. Statistical analyses were performed with IBM SPSS Statistics for Windows, version 24 (IBM Corp). All tests were 2-sided. Statistical significance was set at $P < .05$.

Results

Demographic characteristics of the study population (n = 1239) are summarized in **Table 1** and stratified based on BHLS score. The median age was 57.0 years (interquartile range [IQR], 46-67) and 1083 (87.4%) of the patients were white. The mean (SD) BHLS score was 12.9 (2.76) and the median educational attainment was 13.0 years (IQR, 12.0-16.0). For the entire cohort, 86 patients (6.9%) had a low BHLS score (3-8 points), 244 (19.7%)

Table 2. Multivariate Linear Regression Analysis With Length of Stay as the Dependent Variable

	β (95% CI)	*P* Value
Age, y	0.002 (−0.02 to 0.024)	.877
Sex		
Male	0.211 (−0.41 to 0.83)	.51
Female	1 [Reference]	
Race/ethnicity		
White	1 [Reference]	
Black	1.455 (0.30-2.61)	.01
Other	−0.313 (−1.77 to 1.15)	.67
BHLS[a]	−0.139 (−0.26 to −0.02)	.02
Education, y	0.062 (−0.06 to 0.18)	.18
Charlson Comorbidity index	−0.015 (−0.12 to 0.09)	.78
ASA class		
2	1 [Reference]	
3	1.057 (0.35-1.77)	.14
4	7.188 (5.34-9.04)	<.001
Procedure (resection)		
Colorectal	1 [Reference]	
Gastric	0.461 (−1.18 to 2.11)	.58
Pancreatic	2.151 (1.28-3.02)	<.001
Hepatic	−1.309 (−2.15 to −0.47)	.002
Complications	5.629 (4.75-6.51)	<.001
Insurance status		
Private/commercial	1 [Reference]	
Medicare/Medicaid	0.065 (−0.57 to 0.70)	.841
Uninsured	−0.519 (−2.11 to 1.07)	.522

Abbreviations: ASA, American Society of Anesthesiologist; BHLS, Basic Health Literacy Screen.

[a] BHLS used as a continuous variable.

Table 3. Multivariate Logistic Regression Analysis With 90-Day Readmission as the Dependent Variable

	Adjusted Odds Ratio (95% CI)	*P* Value
Age, y	0.992 (0.98-1.00)	.14
Sex		
Male	1.006 (0.76-1.34)	.97
Female	1 [Reference]	
Race/ethnicity		
White	1 [Reference]	
Black	0.723 (0.41-1.29)	.27
Other	0.802 (0.39-1.65)	.55
BHLS[a]	0.970 (0.92-1.02)	.27
Education, y	1.032 (0.98-1.09)	.25
Charlson Comorbidity index	1.002 (0.95-1.05)	.94
ASA class		
2	1 [Reference]	
3	0.909 (0.66-1.26)	.57
4	1.234 (0.55-2.75)	.61
Procedure (resection)		
Colorectal	1 [Reference]	
Gastric	0.901 (0.42-1.93)	.79
Pancreatic	0.927 (0.62-1.38)	.71
Hepatic	0.717 (0.48-1.08)	.11
Complications	3.757 (2.64-5.34)	<.001
Insurance status		
Private/commercial	1 [Reference]	
Medicare/Medicaid	0.812 (0.60-1.09)	.17
Uninsured	0.926 (0.44-1.95)	.84

Abbreviations: ASA, American Society of Anesthesiologist; BHLS, Basic Health Literacy Screen.

[a] BHLS used as a continuous variable.

had an intermediate BHLS score (9-11 points), 278 (22.4%) had an intermediate-high BHLS score (12-14 points), and 631 (50.9%) had a high BHLS score (15 points). Seven-hundred thirty-one patients (59%) of patients underwent a colorectal resection, 237 (19.1%) a hepatic resection, 216 (17.4%) a pancreatic resection, and 51 (4.1%) a gastric resection.

Lower BHLS scores were associated with increasing age (IQR, 52-67; $P < .001$), lower level of attained education (IQR, 12-16; $P < .001$), higher ASA class (SD, 55; $P < .001$), procedure type ($P = .002$), increased intensive care unit LOS (SD, 4.9; $P = .01$) and hospital LOS (IQR, 4-8; $P = .004$) on bivariate analyses. For the entire cohort, presentation to the ED within 30 days of discharge was 14.7% (n = 182) and hospital readmission within 90 days of discharge was 21.4% (n = 265). Patients with the lowest HL levels (BHLS, 3-8) remained in the hospital a median of 1 day longer than did those patients with the highest HL levels (BHLS, 15).

Linear regression modeling for LOS, shown in **Table 2**, demonstrated that ASA class 3 (β=1.057; 95% CI, 0.35-1.77; $P = .004$), ASA class 4 (β=7.188; 95% CI, 5.34-9.04; $P < .001$), undergoing pancreatic resection (β=2.151; 95% CI, 1.28-3.02; $P < .001$), and postoperative complications (β=5.629; 95% CI, 4.75-6.51; $P < .001$) were independently associated with longer LOS. Patients with a lower HL score had a longer LOS (β= −0.139 per point change in BHLS; 95% CI, −0.26 to −0.02; $P = .02$). Patients who underwent hepatic resections also had a shorter LOS (β= −1.309; 95% CI, −2.15 to −0.47; $P = .002$).

Logistic regression modeling demonstrated that postoperative complications were predictive of increased rates of ED visits within 30 days of discharge (odds ratio [OR], 3.14; 95% CI, 2.12-4.65; $P < .001$) as well as increased rates of hospital readmission within 90 days of discharge (OR, 3.76; 95% CI, 2.64-5.34; $P < .001$). However, HL was not predictive of ED visits within 30 days of discharge (OR, 0.97; 95% CI 0.92-1.04; $P = .39$), nor was it predictive of hospital readmission within 90 days of discharge (OR, 0.97; 95% CI 0.92-1.03; $P = .30$). Logistic regression modeling for 90-day hospital readmission is shown in **Table 3**.

Discussion

To our knowledge, this is the first study to investigate surgical outcomes associated to a patient's HL level among a population undergoing major abdominal surgery. Interestingly, the BHLS was initially formulated, tested, and later validated within ambulatory surgery populations,[27,34] but until now it has not been used to assess postoperative surgical outcomes among those undergoing major, inpatient abdominal surgery.

We found that lower HL levels were associated with an increased LOS during index hospitalization, such that patients with low HL levels (BHLS 3-8) spent an additional median of 1 day in the hospital compared with those with a high HL level (BHLS, 15). Discharge from the hospital represents a complex transition in the lives of patients. As patients approach impending discharge they can experience a sense of lack of control over their impending recovery and self-care.[35,36] Elderly patients who are discharged with surgically placed enteral access (ie, gastrostomy or a jejunostomy tube), for example, often feel inundated with new information and instructions, leading to fears of an inability to cope with potential complications or difficulties with use at home.[37] We suggest that surgical patients with low HL levels require additional time and resources for discharge teaching and instruction (eg, management of surgically placed drains, wound care management, dietary changes), arranging home-health needs, and managing general anxiety regarding self-care during surgical disability once out of the hospital.

However, HL was not associated with postdischarge outcomes, namely 30-day ED visits or 90-day hospital readmissions. These findings contrast with other studies within chronic medical populations.[16-18] We offer several hypotheses to help explain this distinction.

First, all patients in this study were undergoing elective procedures and patients were medically optimized preoperatively. For the most part, patients were discharged without receiving new medical diagnoses or medications, except for the addition of temporary, symptom-relieving medications (eg, analgesics, antiemetics, and bowel regimen). Perhaps the relative medical stability among this elective surgical population mitigated the potential effects of low HL levels on postdischarge health care use.

Second, surgical patients are routinely evaluated within 2 to 4 weeks following a discharge in the postoperative, follow-up visit, most often with the same surgical team. This appointment is not only useful in evaluating the expected postoperative recovery process, but it also allows patients to address any unexpected postoperative concerns or changes in physiology or symptoms and to obtain refills in medications and supplies. This early postoperative visit may play an important role in the ability of the health care system to detect and address problems early before they result in unnecessary ED visits or hospital readmissions. Among patients who were admitted for acute medical conditions, however, a routine postdischarge continuity visit is often not present.

Strengths and Limitations

This study has several limitations. This is a single-institution, retrospective review and thus lacks the power and generalizability of a prospective study. The study patient population was 87% white with a mean of 13.0 years of highest education. Just over half (51%, n = 632) of the study population had a BHLS score of 15, concordant with proficient or high HL levels, while 6.9% (n = 85) of the study population had low BHLS scores (3-8). These characteristics are reflective of a patient population within one urban tertiary referral center. However, we did not assess any risky health behaviors (alcohol, tobacco, or drug use) of the patients in this particular study, but these will be evaluated in future studies.

Additionally, a general underlying limitation with readmission analyses among surgical populations is the assumption of patient follow-up or representation within the same hospital system in which the index procedure was performed.[38] Health literacy may have a more influential role on postdischarge health care use within the surgical population (ie, readmission, ED visits), but the data are not available for collection and analysis. We also did not assess the association with HL levels on discharge dispositions (eg, home health, inpatient rehabilitation, skilled nursing facility). However, unlike readmission and ED visits, LOS is captured 100% of the time via the electronic medical record, adding to the strength of our observed findings.

These results show an opportunity for hospital systems to improve the inpatient experience, decrease potential adverse events, and decrease overall costs. Approximate costs and capacity analyses at the home institution of the authors suggests that if patients within this cohort with a low HL level could achieve the same LOS as the group with high HL, a savings of 1 bed-days per patient, the hospital would save approximately $61 000 per annum, and the early release of beds would add additional inpatient capacity, which would result in additional revenue. Thus, if a patient can be identified as having a low HL level during one of the several perioperative interactions (initial surgical consultation, preoperative holding room, daily rounds, and follow-up appointments), clinicians are given an opportunity to focus more attention on ensuring patient understanding and comfort. Any means by which patients with low HL levels can be identified early may offer opportunities for interventions to achieve a shorter hospital LOS. For example, this could be accomplished by using additional visual aids, using less technical language, and slowing or repeating the delivery of information.

Future studies plan to include prospective cost analyses among this surgical population and the identification of any effects of preoperative identification of those with low HL may have on cost reduction, given the demonstrated effect on LOS and hospital bed use. Additionally, an effectiveness-implementation hybrid randomized clinical trial, as proposed by Curran et al,[39] could be used in which we test the effects (effect on LOS) of a proposed intervention (eg, focused preoperative or postoperative teaching sessions) for those with low HL levels, while, at the same time, focusing on implementation of interventions within our institution.

However, the most important aim moving forward is the continued education on HL and its effects on outcomes to clinicians, specifically house-staff members and advance practice nursing personnel who may spend more time performing patient education, discharge planning, scheduling, and other tasks.[40]

Conclusions

Lower HL is independently associated with increased LOS in patients who are undergoing major abdominal surgery. In this study, lower HL status is not associated with increased 30-day ED visits or 90-day hospital readmissions in the same patient population.

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REFERENCES

1. Nielsen-Bohlman L. *Institute of Medicine. Health Literacy: A Prescription to End Confusion*. Washington, DC: The National Academies Press; 2004.

2. 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(2):97-107.

3. Kutner MA. *The Health Literacy of America's Adults: Results From the 2003 National Assessment of Adult Literacy*. Washington, DC: National Center for Education Statistics; US Department of Education; 2006.

4. US Census Bureau. Population. http://www.census.gov/topics/population.html. Accessed February 12, 2017.

5. Williams MV, Baker DW, Parker RM, Nurss JR. Relationship of functional health literacy to patients' knowledge of their chronic disease. a study of patients with hypertension and diabetes. *Arch Intern Med*. 1998;158(2):166-172.

6. Mancuso CA, Rincon M. Impact of health literacy on longitudinal asthma outcomes. *J Gen Intern Med*. 2006;21(8):813-817.

7. Williams MV, Baker DW, Honig EG, Lee TM, Nowlan A. Inadequate literacy is a barrier to asthma knowledge and self-care. *Chest*. 1998;114(4):1008-1015.

8. Osborn CY, Cavanaugh K, Kripalani S. Strategies to address low health literacy and numeracy in diabetes. *Clin Diabetes*. 2010;28(4):171-175. doi:10.2337/diaclin.28.4.171

9. Schillinger D, Bindman A, Wang F, Stewart A, Piette J. Functional health literacy and the quality of physician-patient communication among diabetes patients. *Patient Educ Couns*. 2004;52(3):315-323.

10. Wu JR, Moser DK, DeWalt DA, Rayens MK, Dracup K. Health literacy mediates the relationship between age and health outcomes in patients with heart failure. *Circ Heart Fail*. 2016;9(1):e002250.

11. McNaughton CD, Cawthon C, Kripalani S, Liu D, Storrow AB, Roumie CL. Health literacy and mortality: a cohort study of patients hospitalized for acute heart failure. *J Am Heart Assoc*. 2015;4(5):e001799.

12. Peterson PN, Shetterly SM, Clarke CL, et al. Health literacy and outcomes among patients with heart failure. *JAMA*. 2011;305(16):1695-1701.

13. Wu JR, Holmes GM, DeWalt DA, et al. Low literacy is associated with increased risk of hospitalization and death among individuals with heart failure. *J Gen Intern Med*. 2013;28(9):1174-1180.

14. Cavanaugh KL, Osborn CY, Tentori F, Rothman RL, Ikizler TA, Wallston KA. Performance of a brief survey to assess health literacy in patients receiving hemodialysis. *Clin Kidney J*. 2015;8(4):462-468.

15. Dageforde LA, Box A, Feurer ID, Cavanaugh KL. Understanding patient barriers to kidney transplant evaluation. *Transplantation*. 2015;99(7):1463-1469.

16. Baker DW, Parker RM, Williams MV, Clark WS. Health literacy and the risk of hospital admission. *J Gen Intern Med*. 1998;13(12):791-798.

17. Bailey SC, Fang G, Annis IE, O'Conor R, Paasche-Orlow MK, Wolf MS. Health literacy and 30-day hospital readmission after acute myocardial infarction. *BMJ Open*. 2015;5(6):e006975.

18. Mitchell SE, Sadikova E, Jack BW, Paasche-Orlow MK. Health literacy and 30-day postdischarge hospital utilization. *J Health Commun*. 2012;17(suppl 3):325-338.

19. Chew LD, Bradley KA, Flum DR, Cornia PB, Koepsell TD. The impact of low health literacy on surgical practice. *Am J Surg*. 2004;188(3):250-253.

20. Scarpato KR, Kappa SF, Goggins KM, et al. The impact of health literacy on surgical outcomes following radical cystectomy. *J Health Commun*. 2016;21(sup2):99-104.

21. Merkow RP, Bentrem DJ, Cohen ME, et al. Effect of cancer surgery complexity on short-term outcomes, risk predictions, and hospital comparisons. *J Am Coll Surg*. 2013;217(4):685-693.

22. Paruch JL, Merkow RP, Bentrem DJ, et al. Impact of hepatectomy surgical complexity on outcomes and hospital quality rankings. *Ann Surg Oncol*. 2014;21(6):1773-1780.

23. Zite NB, Wallace LS. Use of a low-literacy informed consent form to improve women's understanding of tubal sterilization: a randomized controlled trial. *Obstet Gynecol*. 2011;117(5):1160-1166.

24. LoVerde ME, Prochazka AV, Byyny RL. Research consent forms: continued unreadability and increasing length. *J Gen Intern Med*. 1989;4(5):410-412.

25. Davis TC, Wolf MS, Bass PF III, et al. Low literacy impairs comprehension of prescription drug warning labels. *J Gen Intern Med*. 2006;21(8):847-851.

26. Cawthon C, Mion LC, Willens DE, Roumie CL, Kripalani S. Implementing routine health literacy assessment in hospital and primary care patients. *Jt Comm J Qual Patient Saf*. 2014;40(2):68-76.

27. Chew LD, Bradley KA, Boyko EJ. Brief questions to identify patients with inadequate health literacy. *Fam Med*. 2004;36(8):588-594.

28. Chew LD, Griffin JM, Partin MR, et al. Validation of screening questions for limited health literacy in a large VA outpatient population. *J Gen Intern Med*. 2008;23(5):561-566.

29. Wallston KA, Cawthon C, McNaughton CD, Rothman RL, Osborn CY, Kripalani S. Psychometric properties of the brief health literacy screen in clinical practice. *J Gen Intern Med*. 2014;29(1):119-126.

30. McNaughton CD, Kripalani S, Cawthon C, Mion LC, Wallston KA, Roumie CL. Association of health literacy with elevated blood pressure: a cohort study of hospitalized patients. *Med Care*. 2014;52(4):346-353.

31. Dageforde LA, Cavanaugh KL, Moore DE, et al. Validation of the written administration of the short literacy survey. *J Health Commun*. 2015;20(7):835-842.

32. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373-383.

33. ACS-NSQIP. ACS-NSQIP surgical risk calculator 2017; http://riskcalculator.facs.org/RiskCalculator/. Accessed January 9, 2017.

34. Wallace LS, Cassada DC, Rogers ES, et al. Can screening items identify surgery patients at risk of limited health literacy? *J Surg Res*. 2007;140(2):208-213.

35. Clark PA, Drain M, Gesell SB, Mylod DM, Kaldenberg DO, Hamilton J. Patient perceptions of quality in discharge instruction. *Patient Educ Couns*. 2005;59(1):56-68.

36. Lithner M, Klefsgard R, Johansson J, Andersson E. The significance of information after discharge for colorectal cancer surgery-a qualitative study. *BMC Nurs*. 2015;14:36.

37. Hitchings H, Best C, Steed I. Home enteral tube feeding in older people: consideration of the issues. *Br J Nurs*. 2010;19(18):1150-1154.

38. Yermilov I, Bentrem D, Sekeris E, et al. Readmissions following pancreaticoduodenectomy for pancreas cancer: a population-based appraisal. *Ann Surg Oncol*. 2009;16(3):554-561.

39. Curran GM, Bauer M, Mittman B, Pyne JM, Stetler C. Effectiveness-implementation hybrid designs: combining elements of clinical effectiveness and implementation research to enhance public health impact. *Med Care*. 2012;50(3):217-226.

40. Kripalani S, Weiss BD. Teaching about health literacy and clear communication. *J Gen Intern Med*. 2006;21(8):888-890.