

ROLE OF HEALTH LITERACY IN TOTAL KNEE ARTHROPLASTY
IN OLDER ADULTS WITH KNEE OSTEOARTHRITIS

By

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To my husband, Dad, Mom, and my brother

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Abstract of Thesis Presented to the Graduate School
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WITH KNEE OSTEOARTHRITIS

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Health literacy is an important determinant of healthcare utilization. This is thought to be related to inability for an individual with limited health literacy to advocate for his/her healthcare needs. We sought to determine whether health literacy is associated with the use of total knee arthroplasty (TKA)—an effective procedure to palliate an important cause of disability in older adults—osteoarthritis of the knee.

Our specific aim was to investigate the association of health literacy with the utilization of TKA among older adults with knee OA. We hypothesize that older adults with limited health literacy have a decreased utilization of TKA for treatment of knee OA.

The study included 889 black and white community-dwelling men and women aged 70-79 years participating in the Health, Aging and Body Composition Study (Health ABC Study)—a 10-year longitudinal cohort study. Participants were recruited in either Memphis, TN, or Pittsburgh, PA. They were all high functioning at baseline without dementia, functional difficulties, or life-limiting cancer. Participants took health literacy (HL) assessment during their clinical visits in year 3, using the Rapid Estimate of Adult Literacy of Medicine (REALM). They were excluded from the study if they had prior history of TKA or having no knee pain, aches or stiffness in either knee for most days of the week in the past 30 days. The REALM

score was dichotomized into limited HL (=REALM score 0-60) and adequate HL (= REALM score 61-66). The incidence of the first TKA surgery was assessed from year 3 through year 9 of the Health ABC Study. Descriptive statistics, chi-square test, Wilcoxon rank test and logistic regression were used to analyze the relationship of HL with TKA.

Overall, participants (n=889) were 40% male, 48% lived in Memphis, 49% had annual household income less than \$25,000, 37% reported their health status to be very good or excellent, 56% Caucasians, 24% had less than high school equivalency, 97% reported having a usual source of healthcare, and advice, 24% had limited health literacy. Their mean age was 73.5 ± 2.9 years and body mass index of 28.5 ± 5.1 kg/m². The overall incidence of TKA was 6.7%. The incidence of TKA varied significantly by HL—8.1% among persons with adequate HL and 1.9% among persons with limited HL (p=0.0014). We removed body mass index, annual household income, health status, age, depression and usual source of healthcare and advice from the logistic regression model because they had no significant relationship with TKA (p \geq 0.1). Cognitive function was also removed from the model because it was highly collinear with HL and TKA, and had a suppressive effect on the relationship of HL with TKA. The significant association of HL with TKA persisted after adjusting for knee pain, race, education and clinical site (p=0.03).

In this cohort of well-functioning older adults, limited health literacy was associated with a decreased utilization of TKA. Future interventions to prevent disability in older adults may be more successful if the role of health literacy is better understood.

CHAPTER 1 INTRODUCTION

Background

Scope of Problems of Knee Osteoarthritis

Osteoarthritis (OA)—also known as degenerative joint disease—is the most common rheumatologic disease that results in significant disability among middle-aged and older persons. In 2005, estimated prevalence of OA was 46 million: 1 in 5 adults in the United States(1). Osteoarthritis (OA) placed third among the leading causes of disability in the U.S. with approximately 1 million years lived in disability and \$13.2 billion in annual job-related costs due to OA. Because of the considerable impact of OA on public health, the U.S. Public Health Service *Healthy People 2010* included an agenda on decreasing health disparity associated with OA(2).

The knee is the most common joint affected by OA. The estimated prevalence of symptomatic knee OA is 16 % among U.S. adults over 45 years old (18.7% female, 13.5% male) (3), and the annual incidence of symptomatic knee OA is 240 per 100,000 person years(4). Knee OA also results in destruction of the knee joints, which appears on knee radiographs in 0.9% of U.S. adults(5). Chronic joint pain, aching and stiffness in the knee can cause functional limitation in 40% of knee OA patients in performing one of these activities—walking, stair climbing, performing heavy home chores, carrying heavy objects, house keeping, cooking and grocery shopping. Due to the significant pain and immobility, 14% need assistance in personal care on the daily basis(6). Furthermore, knee OA significantly decreases patients' quality of life as 40% of them reported either poor or fair health. With the expected growth of older segment of the U.S. adult population in the future, knee OA will continue to place enormous healthcare and economic burdens in the U.S(7).

Utilization of Total Knee Arthroplasty

Among treatment options available for knee osteoarthritis (OA), total knee arthroplasty (TKA) is a surgical treatment to replace a diseased native knee joint with a prosthetic joint. Total knee arthroplasty (TKA) ranks at or near the top among medical and surgical interventions in its cost-effectiveness as it alleviates knee pain, restores physical function and improves the quality of life in patients with an advanced stage of knee OA(8). Previous studies reported that the effect sizes of short-term and long-term pain and functional outcomes of TKA ranged from 1.27 to 3.91(9). The complication rates are low—the mortality rate 0.5%, hospital readmission rate 0.9%, pulmonary embolism 0.8%, wound infection 0.4%, pneumonia 1.4% and myocardial infarction 0.8%(8).

In spite of its clinical benefits, TKA also has significant tradeoffs. The failure rate of prosthetic joints is moderately high—10% at 10 years and 20% at 20 years after initial TKA. Failed prosthetic joints will require revision surgery which has higher surgical complication rates than initial TKA(10;11). Although TKA is safer than other orthopedic surgeries(8), TKA is still riskier than any other non-surgical interventions for knee OA. These non-surgical interventions include physical therapy, analgesics and anti-inflammatory medications that are primarily prescribed to provide temporary relief of pain and physical function with variable efficacy(12). In addition, post-surgical care of TKA requires a prolonged period of intensive physical therapy—from weeks to months—in restoring physical function, which makes TKA an inconvenient treatment option to patients(12). Because of these tradeoffs of TKA, clinical guidelines consensus groups agreed that TKA is indicated only at an advanced stage of knee OA in which patients' function has declined to an unacceptable level and failed to respond to other non-surgical treatments of knee OA(12;14).

Despite of these tradeoffs of TKA, the number of TKA performed in the United States has steadily increased over the past 15 years. Between 1993 and 2005, TKA was the second fastest growing reason for orthopedic-related hospital admissions among Medicare enrollees, with 89% growth in the number of hospital admissions due to TKA(15). It also is the most frequently performed elective orthopedic surgeries in the U.S. with approximately 478,000 TKA surgeries were performed annually, accounting for one-quarter of all orthopedic-related surgeries(16). In 2000, the Medicare spent a total of \$3.2 billion on TKA(17). As the aging population grows in the U.S. and the indication for TKA broadens with improved performance of new prosthetic joints and advances in surgical techniques of TKA, the Medicare expenditure for TKA is projected to increase by 6-fold in year 2030(18).

Because TKA is a common, elective surgery that contributes to a substantial Medicare expenditure, the utilization of TKA has come under increasing scrutiny. Numerous studies documented considerable racial/ethnic and regional inequality in the utilization of TKA(19). The reason behind the socio-cultural disparity in the utilization of TKA is not well known. However, previous literature implicated a complex interaction of patient-level factors (e.g. treatment preference), provider factors (e.g. surgeons' practice style and physician-patient communication style) and system-level factors (e.g. access to specialist care) as a cause of such disparity(20;21).

Role of Health Literacy in Healthcare Utilization

During the past 15 years, health literacy has emerged as an important patient-level factor that explains the disparity in healthcare utilization(21-23). Health literacy refers to individuals' capacity to obtain, process, and understand basic health information and services needed to make appropriate healthcare decisions(23). A substantial body of evidence indicates that inadequate health literacy significantly impairs patients' knowledge, understanding and decision making

about their own healthcare(22). However, previous studies have primarily investigated the association of inadequate health literacy with the decreased utilization of preventive healthcare services such as influenza vaccination and cancer screening tests for breast, prostate and colon cancers(24-29). Evidence is currently lacking on whether there is an association between health literacy and the utilization of TKA.

Statement of the Problem

Although the preponderance of evidence documents that inadequate health literacy impairs patients' knowledge, understanding and decision making about their own healthcare, little is known about health literacy's role in the utilization of total knee arthroplasty (TKA). Research in this topic is justified at several levels of relevance to the current health care. First, examining health literacy in regards to the utilization of TKA provides a unique health services research model because TKA is a preference-sensitive healthcare. According to Wennberg, et al, a preference-sensitive healthcare entails at least two valid alternative treatment options and the choice of treatment involves trade-offs. Thus, decision making about preference-sensitive healthcare should be based on patient's opinions and values(20). Because having adequate knowledge and understanding about TKA is a pre-requisite for patients to make an informed decision, health literacy may play a critical role in the utilization of TKA. In today's consumer-minded healthcare system in which shared-decision making is important(21), health literacy may present an important paradigm in understanding the access to TKA. Secondly, health literacy is clinically important because it presents an opportunity for an innovative strategy to improve patients' knowledge, understanding and decision making for TKA. Lastly, research is needed to understand the access to TKA in patients with limited health literacy because the majority of TKA surgeries are performed on older patients who commonly use their Medicare benefits to pay for TKA(21;30). Since the disparity in the utilization of TKA is related to federal healthcare

expenditures, health literacy has a significant implication to health policy and research on the disparity in healthcare access to TKA.

For these reasons, it is important that health services research be conducted to investigate the role of health literacy in the utilization of TKA. In this study, we investigated the association of health literacy in the incidence of TKA among older patients with knee OA using available data from the Health, Aging and Body Composition Study (Health ABC Study)—10-year longitudinal cohort study of older adults. We hypothesize that limited health literacy is associated with the decreased incidence of TKA—an effective procedure to palliate an important cause of disability in older adults – osteoarthritis (OA) of the knee.

Specific Aim and Hypothesis

Our specific aim was to investigate the association of health literacy with the utilization of TKA among older adults with knee OA. We hypothesize that older adults with limited health literacy have a decreased utilization of TKA for treatment of knee OA.

CHAPTER 2 METHODS

Participants

Data were available from the Health ABC Study—a 10-year longitudinal cohort study of older adults from 1997 through 2006. This study—funded by the National Institute of Aging with the National Institute of Health—aims to investigate the epidemiology, demographics and biometry associated with the decline in functional status and change in body composition of older persons in transition from wellness to frailty(31). In 1997, investigators from the University of Pittsburgh (Pittsburgh, Pennsylvania) and the University of Tennessee (Memphis, Tennessee) recruited 3,075 English-speaking participants aged 70 to 79 years from a random sample of white Medicare beneficiaries and all age-eligible African American community residents to participate in the study. All participants were well functioning at baseline. The eligibility criteria included self-reporting no difficulty in walking a distance of 400 meters or climbing at least 10 stairs, free of life-threatening cancers, independently performing activities of daily living and plans to living in the area for the next 3 years. Of baseline participants, 46% of the women and 37% of the men were African Americans. Residents within designated ZIP codes were mailed study brochures and then called on the phone to request study participation and assess their functional status.

During the annual clinical visits in year 3 of the Health ABC Study (1999/2000), an in-person clinical assessment of health literacy was performed in 2,512 participants. Of the original 3,075 participants, 563 subjects did not complete health literacy assessment because of lack of an in-person clinic interview (n=418), death (n=107), poor eye sight (n=14), refusal (n=13), withdrawal from the study (n=6), and missing data (n=5)(24). Only the participants who completed health literacy assessment (n=2512) were included in the study. Participants were

excluded from the study if they had: 1) prior history of TKA (n=29), or 2) having no knee pain, aches or stiffness in either knee for most days of the week for the past 30 days (n=1,594). Eight hundred and eighty-nine participants were included in the study. None of the participants (n=889) reported having diagnoses other than osteoarthritis or degenerative joint disease for their knee pain. The Institutional Review Board of the University of Florida approved this study.

Measures

Health Literacy

The Rapid Estimate of Adult Literacy in Medicine (REALM) was measured during the clinical visits in year 3 of the Health ABC Study. The REALM is a verbal fluency test that measures the ability to pronounce 66 common medical words and lay terms that adult primary care patients are expected to recognize(32). These words are presented in the order of increasing difficulty and syllable length, with one point given for each word pronounced correctly. These words were originally chosen from patient education materials and patient intake forms used in university-based primary care clinics. Item reduction from 125 to 66 words was based on psychometric estimates of item difficulty and discrimination and the frequency of retained words in written materials given to patients. It has a high concentration of words at lower difficulty levels, which increases its discriminatory power when administered to patients with limited reading ability. Participants are asked to read aloud as many words as they can, beginning with the first word in the first column. When they encounter a word they cannot read, they asked to do the best they can or say “blank” and go onto the next word. The raw score is the number of correctly pronounced words with the dictionary pronunciation taken as the scoring standard(32).

The REALM scores range from 0 to 66 from the lowest to the highest health literacy. Examples of words in the REALM are ‘fat’, ‘pill’, ‘exercise’, ‘arthritis’, ‘medication’ and ‘obesity’. The REALM has a high face validity and criterion validity because it correlated well

with three other standardized reading recognition tests– 1) the revised Wide Range Achievement Test-Third Edition (WRAT-3) ($r=0.88$), 2) the Slosson Oral Reading Test-Revised (SORT-R) ($r=0.96$), and 3) the Peabody Individual Achievement Test-Revised (PIAT-R) ($r=0.97$)(33). The REALM also correlated well with other standardized health literacy tests such as the Test of Functional Health Literacy in Adults (TOHFLA) ($r=0.84$)(34) and the short version of the TOHFLA(35). The REALM has a high test-retest reliability ($r=0.99$) and inter-rater reliability ($r=0.99$) among 100 adults(33). The 66-item version of the REALM takes 1-2 minutes to complete by personnel with minimal training. Uniform administration and scoring of the REALM was achieved by standardized training and direct observation of a subset of test administrations.

The raw REALM scores were used to derive U.S. high school grade range estimates(32). The grade level was determined by linear regression analysis using the REALM raw scores to predict scores on the Slosson Oral Reading Test-Revised (SORT-R), which is a widely used national standardized test in the U.S. The REALM scores were categorized into four levels to estimate the reading ability(33;36). The first level (REALM score range: 0 to 18) approximates a reading level of 3rd grade or less. At this level, participants may not be able to read materials written even at or below the 3rd-grade reading level and may need repeated oral instructions in order to understand most patient education materials that were written at a higher reading level. The second level (REALM score range: 19 to 44) approximates a 4th- to 6th-grade reading level. At this level, participants may be able to read low-literacy materials, but may not be able to read instructions written on a prescription medication label. The third level (REALM score range: 45-60) approximates a 6th to 8th-grade reading level. At this level, participants may be able to read instructions written on a prescription medication label, but may struggle with currently

available patient education materials that are mostly written at or above the 9th-grade reading level. The fourth level (REALM score range: 61-66) approximates a 9th-grade reading level and above. At this level, participants may be able to read most of the currently available patient education materials. Because of a small sample size in the first and second levels of the REALM, we combined them to create a three-level ordinal variable (REALM score range: 0-44, 45-60, and 61-66). The REALM score was also dichotomized into 2 levels by combining the first 3 levels of the original four-level ordinal variable. We defined the 2 levels of the dichotomized variable as follows: 1) Limited health literacy if the REALM score is 0 through 60, and 2) Adequate health literacy if the REALM score is 61 through 66.

Total Knee Arthroplasty

The incidence of total knee arthroplasty (TKA) was defined as the participants' first hospitalization events due to TKA that they had ever had in their life. Data on hospitalization events were available in the Detailed Hospitalization Listing dataset of the Health ABC Study that contains information about hospitalization that resulted in at least an over-night stay in a hospital. The study examiners initially obtained the hospitalization events from participants during annual in-person follow-up visits and semi-annual phone call contacts with participants. Information on the hospitalization events such as admission and discharge dates, diagnoses and procedures performed during the hospitalization were adjudicated by reviewing medical records. This adjudicated information on the hospitalization was subsequently entered into the Detailed Hospital Listing dataset. At the time of this study, the hospitalization data were available from year 1 (1997) at baseline clinical visits through November 20, 2007, when participants were last contacted(37). In the Detailed Hospital Listing dataset, we censored hospitalization events due to TKA if they met two criteria—1) osteoarthritis was the primary diagnosis for the hospitalization, and 2) TKA was the primary procedure performed during hospitalization.

Demographic Characteristics

Demographics were obtained at baseline in year 1. The demographic characteristics were age, gender, race/ethnicity (Caucasian or African American), education (<High school equivalency, ≥High school equivalency, ≥ College Graduation with a bachelor's degree), annual household income (< \$25,000, >\$25,000 or Missing) and clinical site (Memphis, Tennessee, or Pittsburgh, Pennsylvania), and whether they had a usual source of healthcare and advice. There was a large number of missing observations in the annual family income. Because income is an important socioeconomic variable that may affect the utilization of TKA, we included missing observations as a level in the income variable. Since the demographics were obtained from participants only once in year 1, we assumed that these demographics were constant throughout this study.

Clinical Characteristics

Participants' clinical characteristics were obtained in year 3 and included—1) body mass index (BMI) calculated as participants' body weight divided by their body height squared (kilogram/meter²), 2) self-report of whether participants had a usual access to healthcare and advice, 2) knee pain measured by a short version of the Western Ontario McMaster Universities (WOMAC) Osteoarthritis Index, 3) depression measured by the Centers for Epidemiologic Studies Depression 10-Item (CESD-10), and 4) cognitive function measured by the Teng's Modified Mini-Mental Status Exam (3MS). Knee pain, Depression and Cognitive function variables are described below in more detail.

Knee pain

The short version of the Western Ontario McMaster Universities (WOMAC) Osteoarthritis Index is a valid, reliable, and responsive measure of pain and function in knee OA(38). The original long version of this index included 17 items addressing the degree of

difficulty in accomplishing 24 activities of daily life in 3 major domains—1) pain (=5 items), 2) stiffness (=2 items), and 3) function (=17 items)(39). The long-version of the WOMAC Osteoarthritis Index has been shortened to increase its applicability in epidemiologic studies, clinical trials and daily clinical practices. The procedures used to derive the short version of the WOMAC Osteoarthritis Index relied on statistical approaches as well as the perceived importance of the items in the WOMAC Osteoarthritis Index by patients and physicians(38). In this study, we used the short version of the WOMAC Osteoarthritis Index that consisted of a questionnaire asking participants whether they had pain, aches or stiffness in either knee on most days of the week for the past 30 days with the following six activities—1) Walking on a flat surface, 2) Going up or down stairs, 3) at night while in bed, 4) Standing upright, 5) Getting in or out of a chair, and 6) Getting in or out of a car. Participants rated their pain with each activity by 5-point Likert scale (0-4: from no pain to extreme pain) with a possible score range from 0 to 24.

Depression

The Center for Epidemiological Studies 10-Item Form (CESD-10) is a shortened version of a long version of the CESD. The CESD-10 is a valid, reliable and responsive measure of depression(40). In a 1,206 well-functioning older adults in an health maintenance organization, the CESD-10 demonstrated good reliability with test-retest correlation coefficients ranged from $r = 0.21$ to $r = 0.84$ with an overall correlation of $r = 0.71$ at an average time interval of 22 days. Principal component factor analysis demonstrated that the CESD-10 collapsed into two factors of positive affect and negative affect(40).

In the CESD-10, a study examiner asked participants about their feelings in the past week as described in the following 10 items: 1) I was bothered by things that usually don't bother me; 2) I had trouble keeping my mind on what I was doing; 3) I was depressed; 4) I felt that

everything I did was an effort; 5) I felt hopeful about the future; 6) I felt fearful; 7) My sleep was restless; 8) I was happy; 9) I felt lonely; and 10) I could not get going. For each of the 10 items, the participants were asked how often they had these feeling in the past week in a 4-point Likert scale from 0 to 3—from rarely or none of the time (<1 day) to most or all of the time (3-4 days). The CESD-10 has a possible score range from 0 to 30 - from no depression to severe depression.

Cognitive function

Teng's Modified Mini-Mental Status Exam (3MS) is an extended version of the Folstein's Mini-Mental Status Exam—the most widely used cognitive assessment in clinical and research settings. The 3MS contains four additional subtests – date of birth, place of birth, word fluency and delayed recall of words. The score of the 3MS ranges from 0 to 100 points from severe impairment to no impairment, and a modified scoring procedure permitted assignment of partial credits on some items(41).

Statistical Analyses

First, we performed univariate analyses using summary statistics such as frequency plots, histogram, tests for location and tests for normality to describe the characteristics of each variable. Second, we performed bivariate analyses using the chi-square test for categorical variables and the Wilcoxon rank test or student t-test for numerical variables to compare group differences by the incidence of TKA. Because none of the continuous variables were normally distributed, we performed the Wilcoxon rank test for these analyses. We also performed bivariate analyses to compare the association of participants' characteristics with health literacy. Third, we performed multivariate analyses using logistic regression to test the relationship of health literacy with the incidence of TKA.

We performed separate logistic regression analyses using three different health literacy variables– 1) numerical REALM scores, 2) three-level ordinal health literacy, and 3)

dichotomized health literacy. Because the distribution of the raw REALM scores was significantly deviated from a normal distribution, we attempted transformation of the REALM scores using logarithmic and inverse transformation methods. After transformation, the REALM scores still had a significant deviation from normal. We also performed logistic regression using the three-level ordinal health literacy, but the model did not meet the conversion criteria and had a questionable model's validity. When we performed logistic regression using the dichotomized health literacy, the model met the conversion criteria and had a good model fit. Thus, we used the dichotomized health literacy in the subsequent analyses.

We used the SAS Statistical Software Version 9.1 (SAS Institute, Inc., Cary, North Carolina) to perform statistical analyses.

CHAPTER 3 RESULTS

Descriptive Analyses

Overall, the participants (n=889) were 40 % male, 48 % lived in Memphis, 49% had annual household income less than \$25,000, 37 % reported their health status to be very good or excellent, 56 % Caucasians, 24 % had less than high school equivalency, 97% reported having a usual source of healthcare and advice and 24% had limited health literacy. The participants had a mean age of 73.5 ± 2.9 years, body mass index of 28.5 ± 5.1 kg/m², depression score (CESD-10) of 5.3 ± 4.5 , cognitive function score (3MS) of 90 ± 7.9 , maximum knee pain score of 6.0 ± 4.2 and health literacy score (REALM) of 60.1 ± 11.6 . The overall incidence of total arthroplasty (TKA) in this cohort was 6.9%.

Next, we performed tests for location and normality to describe the frequency distribution of the participants' characteristics. Specifically, we used skewness, kurtosis, minimum, median, maximum, the Shapiro-Wilk test and the Kolomogorov-Smirnov test. Table 3-1 summarizes results of these analyses. None of the numerical variables were normally distributed as indicated by the Shapiro-Wilk and Kolomogorov-Smirnov tests (p-value <0.01). Particularly, the health literacy score (REALM) had a significant deviation from a normal distribution with a median score of 65. It also had a highly negative skewness and positive kurtosis. Based on these findings, we performed subsequent statistical analyses using non-parametric tests.

Bivariate Analyses

We performed bivariate analyses using the chi-square test and Wilcoxon rank test to compare the association of participants' characteristics with health literacy. Results of these analyses are summarized in Table 2. Many of the participants' characteristics were significantly associated with health literacy. Female gender (p=0.005), Pittsburgh site (p<0.0001), annual

household income of \$25,000 or higher ($p < 0.0001$), higher health status, ($p < 0.0001$), Caucasian race ($p < 0.0001$), higher education ($p < 0.0001$), lower body mass index ($p = 0.0003$), higher cognitive function ($p < 0.0001$) and less severe depression ($p < 0.0001$) were more likely to be associated with adequate health literacy. Age ($p = 0.3$), having a usual source of healthcare and advice ($p = 0.4$), and knee pain ($p = 0.2$) were not associated with health literacy.

Next, we performed bivariate analyses to compare the association of participants' characteristics with total knee arthroplasty (TKA). Table 2 summarizes results of these analyses. The incidence of TKA varied significantly by the levels of health literacy – 8.1% among participants with adequate health literacy and 1.9% among participants with limited health literacy ($p = 0.014$). Participants' characteristics such as Pittsburgh site ($p = 0.0003$), Caucasian race ($p = 0.05$), higher education ($p < 0.02$), higher knee pain ($p < 0.0001$) and higher cognitive function ($p < 0.0001$) were also significantly associated with the incidence of TKA. Age ($p = 0.42$), gender ($p = 0.36$), annual household income ($p = 0.1$), health status ($p = 0.21$), having a usual source of healthcare and advice ($p = 0.25$), body mass index ($p = 0.16$) and depression ($p = 0.46$) were not associated with the incidence of TKA.

Logistic Regression Analyses

We performed logistic regression analyses to measure the relationship of health literacy with the incidence of TKA. Initially, we entered all the participants' characteristics into the model to test this relationship. According to results of this model, we decided on which variables would be included in the final model. If the variable had a significant relationship with TKA ($p < 0.1$), we included the variable in the final model. We removed body mass index, annual household income, health status, age, depression and usual source of healthcare and advice from the final model because they had no significant relationship with TKA. Knee pain, gender, race, education, school and cognitive function were included in the final logistic regression because

they had a significant relationship with TKA. Additionally, race, education and cognitive function were highly collinear with health literacy and TKA. Thus, we performed logistic regression with and without race, education and/or cognitive function to further investigate the relationship of these variables with health literacy and TKA.

Table 3 summarizes results of the logistic regression analyses. We performed 4 logistic regression models to investigate the relationship of race, education and cognitive function with health literacy and TKA. The cognitive function was most collinear with health literacy because it suppressed the association of health literacy with TKA in the first three models (Models 1, 2 and 3) with no significant association between health literacy and TKA. When the cognitive function was removed from the model (Model 4), the association of health literacy and TKA emerged (p=0.03). The association of knee pain and clinical site with TKA remained significant in all four models.

Table 3-1. Frequency distribution of the participants' characteristics

Characteristics	Skewness	Kurtosis	Min	Median	Max.	Shapiro-Wilk (p-value)	Kolomogorov-Smirnov (p-value)
Age	0.35	-0.96	67	73	80	<0.0001	<0.01
Body mass index	0.67	0.95	16.8	27.8	52.1	<0.0001	<0.01
Knee pain	1.1	1.14	1	5	24	<0.0001	<0.01
Cognitive function	-1.67	5.33	33	92	100	<0.0001	<0.01
Depression	1.05	0.89	0	4	23	<0.0001	<0.01
Health literacy	-3.03	9.64	0	65	66	<0.0001	<0.01

n=889

Table 3-2. Relationship of participants' characteristics with health literacy (HL) and total knee arthroplasty (TKA)

Characteristics	Limited HL (n=213)	Adequate HL (n=676)	P-value	No TKA (n=830)	Had TKA (n=59)	P-value
Age (years), mean ± SD	73.6 ± 2.9	73.4 ± 2.8	0.3	73.5 ± 2.9	73.1 ± 2.4	0.42
Gender						
Male (%)	29	71		94	6	
Female (%)	21	79	0.005	92	8	0.36
Site						
Memphis (%)	34	66		97	3	
Pittsburgh (%)	15	85	<0.0001	90	10	<0.0003
Income						
< \$25,000 per year (%)	34	66		95	5	
≥ \$25,000 per year (%)	10	90		92	8	
Missing income (%)	30	70	<0.0001	91	9	0.10
Health status						
Excellent/very good (%)	19	81				
Good (%)	21	79		92	8	
Fair or poor (%)	37	63	<0.0001	95	5	0.21
Race						
Caucasian (%)	10	90		92	8	
African American (%)	41	59	<0.0001	95	5	0.05
Education						
<High school eq.(%)	61	39		96	4	
≥High school eq.(%)	15	85		94	6	
≥College grad.(%)	5	95	<0.0001	94	6	0.02
Have a usual source of healthcare and advice	24	76	0.4	94	6	0.25
Body mass index, mean ± SD	29.3 ± 5.5	28.2 ± 4.9	0.003	28.4 ± 5.1	29.2 ± 4.3	0.16
Knee pain, mean ± SD	6.5 ± 4.8	5.9 ± 4.0	0.2	5.9 ± 4.1	8.2 ± 4.7	<0.0001
Cognitive function, mean ± SD	82.4 ± 9.4	92.4 ± 5.5	<0.0001	89.7 ± 8.0	93.9 ± 4.2	<0.0001
Depression, mean ± SD	6.7 ± 4.8	4.8 ± 4.3	<0.0001	5.3 ± 4.5	5.2 ± 4.8	0.46
Health literacy						
Adequate (%)				91.9	8.1	
Limited (%)	-	-	-	98.1	1.9	0.014

n=889

Table 3-3. Relationship of health literacy (HL) with total knee arthroplasty—logistic regression

Participants' characteristics	Model 1 No race		Model 2 No education		Model 3 No race or education		Model 4 No cognitive function	
	Estimate±SD	p-value	Estimate±SD	p-value	Estimate±SD	p-value	Estimate±SD	p-value
Limited HL	-0.45±0.29	0.13	-0.40±0.29	0.17	-0.43±0.29	0.13	-0.63±0.29	0.03
Knee pain	0.13±0.03	<0.0001	0.13±0.03	<0.0001	0.13±0.03	<0.0001	0.13±0.03	<0.0001
White race	-	-	0.12±0.16	0.46	-	-	0.19±0.16	0.21
Education								
< High school eq.	0.05±0.30	0.36	-	-	-	-	-0.12±0.29	
≥ High school eq.	-0.24±0.20		-	-	-	-	-0.22±0.20	0.20
Memphis site	-0.40±0.16	0.01	-0.40±0.16	0.01	-0.38±0.16	0.016	-0.47±0.16	0.004
Cognitive function	0.08±0.03	0.009	0.08±0.03	0.009	0.09±0.03	0.004	-	-
-2 log likelihood of intercept		434		434		434		434
-2 log likelihood overall		384		385		386		340
C statistics		0.75		0.75		0.74		0.74

CHAPTER 4 DISCUSSION

Significance of the Study

To our knowledge, this is the first study to demonstrate that health literacy is a predictor of the utilization of total knee arthroplasty (TKA)—an effective surgical treatment for osteoarthritis (OA) of the knee. Previous literature has demonstrated that socioeconomic, geographic and clinical factors such as race, education, income, clinical site and knee pain were the explanatory factors of the utilization of TKA(19;21;30;42;43). The reason behind these differences in the utilization of TKA is not well known. Previous literature implicated a complex interaction of patient-level factors (e.g. treatment preference), provider factors (e.g. surgeons' practice style and physician-patient communication style) and system-level factors (e.g. access to specialist care) as a cause of such disparity(21). However, based on our findings from this study, we conclude that health literacy is a predictor of the utilization of TKA and has more significant effect on the utilization of TKA than race, income or education.

Unlike race, education and income that are generally regarded as immutable, health literacy represents a patient-level factor that can be modified or overcome by providing patients with an innovative strategy that is tailored to their levels of health literacy. For instance, Weng and his colleagues have recently developed a decision aid for patients with knee OA, which consists of an educational videotape(44). This 45-minute video contains evidence-based information on pathogenesis and treatment options for knee OA including TKA. The video also included interviews of patients and physicians on why they chose particular medical or surgical treatment for knee OA. These patient and physician commentaries were supplemented by graphic presentation of data on treatment options for knee OA. Fifty-four African American and 48 Caucasian patients watched the video in a group setting, followed by a focus group meeting

and follow-up questionnaire. Results of this study showed that before the educational intervention, African American patients had a significantly lower expectation of pain and functional improvement after TKA and less willingness to consider TKA than Caucasian patients. After receiving the educational intervention, African American patients had significant improvement in their expectation of pain ($p=0.04$) and marginal improvement in their expectation of function ($p=0.09$) after TKA. Caucasian patients had no significant changes in their expectation of pain or function after TKA. Their willingness to consider TKA did not change before and after the educational intervention in either the African American or Caucasian group. Future studies are needed to investigate how a decision aid such as this will influence the process of decision making for TKA in patients with low health literacy.

In this study, we found that 24% of the study participants had limited health literacy—the REALM score of 60 and lower. According to the National Assessment of Adult Literacy (NAAL) in 2003, as many as 43% of the U.S. adult population have a low reading proficiency, and difficulty reading and understanding most health education materials(45). While overwhelming evidence indicated that health literacy is a predictor of healthcare use and health outcomes(22;23), recent evidence suggests that the problem of limited health literacy is often unrecognized because patients are often ashamed and tend to hide their problem by avoiding situations that could expose their lack of understanding(22). Wolf and his colleagues have recently surveyed 313 patients in a general internal medicine clinic and found that limited health literacy was associated with self-reporting difficulty taking medications, need for help with health-related reading tasks and difficulty understanding and following instructions on appointment slips ($p<0.001$). Among these patients, nearly half (47.8%) of patients reading at the 3rd-grade level acknowledged having felt shame or embarrassment about their difficulties

reading, compared with 19.2% of patients reading at the 4th to 6th-grade level, and 6.5% of patients reading at the 7th to 8th-grade level(46). The embarrassment or reluctance of patients to seek more information and discuss with their doctors may delay decision making for effective treatment for knee OA(22), which can manifest as the under-utilization of TKA as we observed in this study.

Role of Cognitive Function in Health Literacy

We also found that participants' cognitive function—assessed by the Teng's Mini-Mental Status Exam (3MS)—had a suppressive effect on the association of health literacy with the utilization of TKA. When the cognitive function was removed from the multivariate regression model, the association between health literacy and TKA improved significantly. Previous literature reported similar findings. For example, in a study of 3,260 community-dwelling adults aged 65 years and older, their health literacy and cognitive function were partly collinear with their mortality. Health literacy also predicted their mortality independently from their cognitive function(47). These results suggest that, while the health literacy assessment shares a common construct with the cognitive assessment, health literacy may also possess a unique construct that is distinct from the construct of the cognitive assessment.

Dichotomization of Health Literacy

In this study, we performed multivariate regression analyses using a dichotomized health literacy variable rather than using numerical scores of the REALM. Most statistical literature on this topic cautioned against dichotomizing a predictor because it will introduce an extreme form of rounding with an inevitable loss of information and power(48;49). If a normally distributed variable is dichotomized at the median, asymptotic efficiency relative to analysis using an ungrouped variable decreases by 35%(49). This means that dichotomizing at the median is equivalent to losing a third of the data and serious loss of power to detect real relationships.

Literature also suggests that a three-level ordinal variable is a better alternative to a dichotomized variable in a logistic regression model(50). However, we believe that recommendations from the statistical literature do not apply to the REALM scores used in this study because the frequency distribution of the REALM had a significant deviation from a normal distribution with highly negative skewness and positive kurtosis. To confirm our belief, we performed logistic regression analyses using three different health literacy variables—numerical, three-level ordinal and dichotomized health literacy. After performing these analyses we found that the dichotomized variable had the best result in preserving the relationship of health literacy with TKA with the most significant p-value ($p=0.03$). Thus, in this study, we performed logistic regression analyses using dichotomized health literacy.

Strength of the Study

The strength of this study is that participants were an inception cohort of a large sample of racially diverse (African Americans vs. Caucasians) and well-functioning older adults at baseline. This prospective cohort design provided evidence that there is a possible causal relationship between health literacy and the utilization of TKA. Also, the incidence of TKA was adjudicated by medical record review, which provided a more accurate account of TKA than self-reported incidence of TKA.

Limitations of the Study

This study also has limitations. First, the REALM was measured only once at baseline during this study. The stability of the REALM scores over time has not been previously reported. However, previous literature suggested that other standardized word recognition tests similar to the REALM appeared to be fairly stable over time and less dependent on subjects' current cognitive function(51). Thus, when we performed the analyses, we assumed that the REALM score was constant throughout the study. Second, the REALM measures a very narrow

construct of health literacy—the ability to pronounce common medical words correctly. However, health literacy will require a set of skills that are much more complex than mere word pronunciation. The REALM has been compared with the Test of Functional Health Literacy in Adults (TOFHLA)—another common assessment of health literacy. The TOFHLA assesses both reading comprehension and numeracy skills related to healthcare issues. It consists of a 50-item reading comprehension test that uses the modified Cloze procedure in which every fifth to seventh word in a healthcare-related passage is omitted and 4 multiple-choice options are provided. One of these 4 choices is correct and 3 of them are similar but grammatically or contextually incorrect. The TOFHLA also contains a 17-item numeracy section that tests a reader's ability to comprehend directions for taking medicines, monitoring blood glucose, keeping medical appointments and obtaining financial assistance(35). While there was a correlation between the REALM and the TOHFLA(34;35), each of these health literacy measures possesses a unique construct that is distinct from one another(32).

Our study is also limited because the results are not applicable to the general population. Participants in this study were all healthy and well-functioning older adults at baseline, who lived in one of two locations—Memphis, Tennessee, or Pittsburgh, Pennsylvania. Furthermore, participants in this study had a much lower prevalence of limited health literacy (24%) than the prevalence of limited health literacy in the general U.S. population (43%)(45). High health literacy among this study cohort could contribute to inaccurate estimation of the incidence of TKA.

CHAPTER 5 CONCLUSIONS

The role of health literacy in healthcare utilization remains an active area of research because health literacy relates to patients' decision making capacity. In today's consumer-minded healthcare system in which shared-decision making is important(21), health literacy may present an important paradigm in understanding the access to TKA. Interventions to prevent disability in older adults may be more successful if the role of health literacy is better understood. Thus, further research is needed to investigate the effect of health literacy on decision making process for TKA among older adults with knee OA—an important cause of disability.

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BIOGRAPHICAL SKETCH

Miho Kojima Bautista grew up in Gifu, Japan. After graduating from high school in Japan, she moved to the United States in 1988, to pursue her goal of developing a career in medicine. She earned her A.A. degree in nutrition from Broward Community College in Fort Lauderdale, Florida, in 1990, and B.S. degree in nutrition from the University of Florida, in Gainesville, Florida, in 1992. Upon her graduation from the University of Florida, she took a position as a clinical nutritionist with the Halifax Medical Center in Daytona Beach, Florida. In her role as a clinical nutritionist, she provided nutritional therapy and counseling to acutely ill patients in the hospital. While she worked full-time at the Halifax Medical Center, she took courses at the Daytona Beach Community College in Daytona Beach, Florida, to prepare for her application to medical school.

In August, 1997, Miho entered medical school at Meharry Medical College in Nashville, Tennessee. Upon earning her M.D. in 2001, she entered residency training in internal medicine with the University of Florida in Gainesville, Florida. During her internal medicine residency, she earned an Excellence in Outpatient Care award from the University of Florida Internal Medicine Residency Program, for her achievement in providing outstanding patient care. On completion of her internal medicine residency in 2004, she entered fellowship in geriatrics medicine with the University of Florida. During her geriatrics medicine fellowship, Miho has successfully competed for and obtained a Geriatric Academic Career Award from the U.S. Department of Health and Human Services. Such an outstanding achievement afforded her many wonderful opportunities including an academic appointment with the UF Department of Medicine and North Florida/South Georgia Veterans Affairs Health System (NF/SGVHS) in 2005, the junior research scholar award from the UF Claude Pepper Older American

Independence Center of Excellence in 2006, and completion of the M.S. program with the UF Advanced Postgraduate Program in Clinical Investigation in 2008.

Upon completion of her M.S. program in 2008, Miho will continue an academic appointment as a Clinical Assistant Professor with the UF Department of Aging and Geriatrics, and staff physician with the NF/SGVHS, Geriatric Research, Education and Clinical Center (GRECC). Miho has been married to Jun Baldoz Bautista for 12 years.