

Alignment of Patient Health Numeracy with Asthma Care Instructions in the Patient Portal

Marilyn M. Schapira, MD, MPH; Chantel Mozal, MPH, PA; Frances S. Shofer, PhD; Rodalyn Gonzalez, BA; and Andrea J. Apter, MD, MSc, MA

ABSTRACT

Background: After Visit Summary (AVS) instructions provided through the patient portal of the electronic medical record can support asthma self-management if patients have the skills to interpret and apply the health information provided. Print literacy demands of patient materials are often higher than the reading ability of patients. However, less is known regarding the numeric demand of patient education materials and how well it aligns with patient health numeracy. **Objectives:** This study (1) developed measures of numeric demand for use in the AVS, (2) described the health numeracy demand of AVS instructions for asthma care, and (3) evaluated the association between numeracy demand of materials and patient health numeracy. **Methods:** We reviewed personalized AVS instructions for an index visit from 74 adults with moderate or severe asthma recruited from clinics serving low-income urban communities. Using measures of numeric complexity and density developed for this study, numeracy demand of the AVS was compared to the numeracy skills of patients using the validated Asthma Numeracy Questionnaire. **Key Results:** The numeric complexity and density scales demonstrated content and face validity. The median (range) of the numeric complexity score for AVS instructions was 2.5 (0-46), and density of numeric information was 8% (0%-33%). The median (range) of the Asthma Numeracy Questionnaire was 2 (0-4). There was no association between patient asthma-related health numeracy and the complexity ($p = .29$) or density ($p = .81$) of numeric information. **Conclusions:** Patient instructions regarding medications and self-management often include numeric information. Lack of alignment of the numeracy demand of materials with health numeracy skill may be a barrier to communication, particularly among patients of lower health numeracy. [*Health Literacy Research and Practice*. 2017;1(1):e1-e10.]

Plain Language Summary: This study developed a way to measure the frequency and complexity of numeric information in instructions given to patients with asthma. No association was found between the difficulty of numeric information provided and the numeracy level of patients. This poses a potential barrier to communication, especially for patients with low health numeracy.

Marilyn M. Schapira, MD, MPH, is a Professor of Medicine, Department of Medicine, Perelman School of Medicine, University of Pennsylvania; and an Investigator, Center for Health Equity Research and Promotion, Philadelphia VA Medical Center. Chantel Mozal, MPH, PA, is a Research Coordinator, Department of Medicine, Perelman School of Medicine, University of Pennsylvania. Frances S. Shofer, PhD, is the Director, Epidemiology and Biostatistics, Department of Emergency Medicine, Perelman School of Medicine, University of Pennsylvania. Rodalyn Gonzalez, BA, is a Research Coordinator, Department of Medicine, Perelman School of Medicine, University of Pennsylvania. Andrea J. Apter, MD, MSc, MA, is a Professor of Medicine, Section of Allergy and Immunology, Department of Medicine, Perelman School of Medicine, University of Pennsylvania.

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Address correspondence to Marilyn M. Schapira, MD, MPH, 1110 Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104; email: mschap@upenn.edu.

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Approximately one-half of adults in the United States have no more than basic reading and numeracy skills and only 20% have the proficiency required to comprehend health information and navigate our health care system (Brach, Dreyer, & Schillinger, 2014). Studies find that health print (reading) literacy demand in patient materials does not match patients' skills (Brach et al., 2014; Baker et al., 2002; Baker et al., 2004). This mismatch is associated with unsatisfactory patient-provider communication and poor health outcomes, caused in part by unsuccessful self-management of chronic diseases such as asthma (Baker et al., 2004; Nielson-Bohlman & Kindig, 2004; Schillinger et al., 2002; Weiss et al., 1994). We previously have reported a positive association between low numeracy and asthma-related emergency department visits and hospitalizations (Apter et al., 2006) and adequate numeracy serving to attenuate the lower asthma-related quality of life observed in patients from minority groups (Apter et al., 2009). The lack of tools for measuring numeracy demand has limited the ability to study the relationship of numeracy skills and demand mismatch with health outcomes.

Numbers and numeric-based concepts are prominent in health-related communication and decision-making. Patients with a chronic illness rely on numeric concepts as part of self-management. For example, patients with asthma self-administer daily medications, monitor their asthma control, and make decisions as to when to seek professional care. A mismatch between patients' numeracy skills and demand of patient instructions may have significant implications for their health management (Apter et al., 2008).

Clinical practices have increasingly used information technology, including the electronic health record (EHR) to communicate with patients. This use arises from the Medicare and Medicaid Electronic Health Records Incentive Programs, designed to promote meaningful use of EHR functions to improve patient care. Indeed, using information technology in promoting health communication is a goal of Healthy People 2020 (Healthy People 2020). A core objective of the meaningful use program and a common feature of most EHRs are to provide patients with an After Visit Summary (AVS). The AVS includes an option for the clinician to provide personalized patient-specific instructions in electronic or paper form, providing an opportunity to tailor information to the clinical context of the patient and the patient level of health literacy. Although patients value information provided in the AVS, patients find some of the information presented difficult to understand (Black et al., 2015).

Prior to the advent of the EHR, studies had shown that instructions to patients were frequently well above patients'

reading levels (Estrada, Hryniewicz, Higgs, Collins, & Byrd, 2000; Schwartz, Woloshin, Black, & Welch, 1997; Spandorfer, Karras, Hughes, & Caputo, 1995; Williams, Counselman, & Caggiano, 1996). Most examinations of patient materials have focused on an individual's print health literacy without consideration of numeracy demands and have not examined the degree that clinicians adjust the instructions according to the individual skills of the patient. There is a lack of validated measures, particularly those that can be computed electronically, to assess numeracy demands of education materials. Numeracy includes a broad range of constructs, including basic arithmetic, tables and graphs, probability, and statistics (Schapira et al., 2008; Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005). The AVS may incorporate a range of these constructs with varying levels of difficulty. Objective measures of numeracy demand are needed to increase clinician awareness of difficult numeric content and prompt the use of communication strategies to optimize patient understanding of information and ability to apply the information in caring for their health.

The goals of this study were to (1) develop measures of numeric demand for use in the AVS, (2) describe the health numeracy demand of AVS instructions for asthma care, and (3) evaluate the association between numeracy demand of materials and patient health numeracy. We hypothesize that there will be a lack of alignment between the numeracy demands of the AVS and patient health numeracy skills. This lack of alignment may pose a barrier to effective communication, especially for patients with low numeracy skills.

METHODS

Study Design and Protocol Summary

We conducted a cross-sectional study. The study population was obtained from two parent clinical trials of adults age 18 years or older with moderate or severe asthma. One trial assessed problem-solving as an intervention to improve adherence to inhaled corticosteroids and asthma outcomes (Apter et al., 2011). The other involved the use of a patient advocate to facilitate access and patient-physician communication to improve adherence and asthma outcomes (Apter et al.; 2013). We defined an index medical visit from which we examined the numeracy and reading levels (demand) of the AVS. The index visit was the first medical visit occurring after January 1, 2010. Numeracy demand was assessed using measures of numeracy complexity and density demand developed for this study (see below). Reading demand was assessed with the Flesch-Kincaid Reading Ease (FKRE) test (Flesch, 1948).

Patients

We selected all patients from the parent trials for whom numeracy and print literacy were assessed and who had personalized patient instructions added by the provider and included in the AVS of the index visit. Participants had moderate or severe persistent asthma as defined by the National Asthma Education and Prevention Program's Expert Panel Report 3 guidelines (2007). They were recruited from primary care and asthma specialty practices within the University of Pennsylvania Health System, practices that serve the residents of low-income neighborhoods in West Philadelphia.

Procedures

Patient data was collected during participation in the parent studies. Data elements collected included sociodemographic factors, asthma history, forced expiratory volume in 1 second (American Thoracic Society, 1995) and assessment of literacy (print and numeric) skills. Individualized instructions to patients were abstracted from the AVS and entered into a Microsoft Office Word (Microsoft, Redmond, WA) document for analysis of readability and numeracy demand.

Measurement of Patient Numeric and Print Literacy

Participants were given the following validated survey instruments: the Asthma Numeracy Questionnaire (ANQ) (Apter et al., 2006) and the reading comprehension portion of the Short Test of Functional Health in Adults (S-TOFHLA) (Baker, Williams, Parker, Gazmararian, & Nurss; 1999). The ANQ is a brief, verbally administered four-item questionnaire of numeric concepts (arithmetic and percentage) adapted from standard asthma education (Apter et al., 2006; Apter et al.; 2013). The Cronbach's alpha of the ANQ in the validation study was .57. The Rasch model was also fit to the ANQ validation data, and goodness of fit tests found no evidence against the Rasch model, indicating that the ANQ was measuring a single trait of health numeracy (Apter et al., 2006). The ANQ score reflects the number of correct answers and ranges from 0 to 4.

The Reading Comprehension portion of the S-TOFHLA consists of 36 modified Cloze procedure items in two sections—one selected from instructions for preparing for an upper gastrointestinal series and one about patients' rights and responsibilities in completing a Medicaid application. A S-TOFHLA score of less than 23 indicates inadequate print health literacy. Scores indicating inadequate health literacy on the TOFHLA correspond to difficulty reading and interpreting health texts (Parker, Baker, Williams, & Nurss, 1995; Nurss, Williams, & Baker, 1995).

Measuring Numeric Complexity and Density

The numeric complexity score is a weighted measure of a set of domains of numeric information. The domains were identified by the investigators (including clinical experts in primary care and pulmonary medicine) as important categories of information for patients with asthma to receive in the AVS. Each domain was weighted with a complexity factor. The weights were determined based on the difficulty of the numeric concept and the tasks involved (such as a calculation). Additional points were added for numeric symbols such as a decimal point, a range, or a percentage. The complexity levels assigned to numeric information were consistent with hierarchical frameworks of health numeracy (Schapira et al., 2008; Golbeck, Ahlers-Schmidt, Paschal, & Dismuke, 2005; Ancker & Kaufman, 2007). The total complexity score was calculated by adding the scores for each document (**Table 1**).

The numeracy density, analogous to the FKRE measure, was calculated by determining the frequency of numeric statements over the frequency of words in the document. Numeric information that included more than one number, such as that represented by fractions or phone numbers, was considered one numeric occurrence. Examples of how the numeric complexity and numeric density scores are calculated are provided in **Figures 1-3**.

Validation of Numeric Complexity and Density Measure

Content validity of the numeracy demand measures were supported by incorporating principles from hierarchical frameworks of health numeracy and mathematics education (Apter et al., 2008; Schapira et al., 2008; Goldbeck et al., 2005). Face validity for the numeric complexity score was assessed by review of documents by volunteers and comparison of perceived difficulty level with the numeric complexity scores. Six volunteer college students were briefed on major elements of the coding scheme and given four examples of patient instructions to rank by difficulty. All six volunteers correctly identified the most and least difficult instruction as measured by the numeric complexity score.

Face validity for the numeric density score was established by identifying health-related documents that were anticipated to be more or less number-based than the average after-visit instruction (a diabetes report card and a flu shot consent form, respectively) and comparing the numeric density scores between these documents. The diabetes report card, thought to be the most difficult, had a density score of 20.7%, whereas the flu shot consent form, thought to be the least difficult, had a density score of 2.2%.

TABLE 1
Coding of Numeric Elements in Complexity Score^a

Domain	Example of an AVS Individualized Instruction	Points
Medication dose	Medication dose (i.e., "continue fluticasone/salmeterol 500/50 twice daily")	1
Self-adjustment of medication	Self-adjustment instructions (i.e., "take 400 mg twice daily for 2 days then decrease to once daily")	1
Risk of outcomes	Risk outcomes associated with asthma or treatment, (i.e., "you increase your risk of osteoporosis by 10%")	1
General goal setting	Setting goals (i.e., optimal home humidity level is 35%-50%")	1
Goal setting requiring a calculation	Setting goals involving a calculation (i.e., "aim for 80% of maximum flow")	1
Dates	Mention of date not associated with dosing (i.e., "make an appointment on January 8")	0.5
Time frame	Time frame not associated with dosing (i.e., "check skin moles every 3 months")	0.5
Numeric symbols	Numbers used in other capacities or range of numbers (i.e., decimals, percentages, or negative numbers, range: 30%-50%, 1-2 weeks, 6-12 months)	0.5

Note: AVS = After Visit Summary.

^aFor example, if an AVS included a medication dose instruction, it would receive 1 point; an additional 1 point would be added if the AVS also included instruction for self-adjustment of the dose.

PID Date	Participants Initials:
EHR and Communication	
Patient Instructions:	
4/19/2010 8:40 AM ; Allergy Ppmc	
Continue Advair	
Flonase 2 puffs in morning	
Allegra daily	
Use peak flow meter if you have symptoms	
Atopic dermatitis: Eucerin and cetaphil	
Please call with concerns or new or worsening symptoms. An allergist is always available 24 hours a day when the clinic is closed. Call and ask to speak with the allergy fellow on-call.	

Figure 1. This is an example of an After Visit Summary and calculation of numeric density and complexity scores (identifying data have been redacted). The numeric density score numerator is 3 (1 point for the "Flonase [GlaxoSmithKline, Middlesex, England] 2 puffs in morning", 1 point for "24 hours", and 1 point for the phone number). The numeric density score denominator is 56, which is the word count, and the word count includes numeric symbols; thus, the numeric density is 3 of 56 (5.4%). The numeric complexity score is 1; 1 point was given for the dosing instruction, "Flonase 2 puffs in morning."

PID Date	Participants Initials
EHR and Communication	
Patient Instructions:	
1/28/2010 ;Pulmonary Ppmc 5 Mutch	
Take prednisone 10 mg daily for 14 days.	
Take biaxin twice daily for 10 days.	
Take other medications as prescribed.	
Return to clinic in 6 weeks.	

Figure 2. This is an example of an After Visit Summary and calculation of numeric density and complexity scores (identifying data have been redacted). The numeric density numerator score is 5 (10 mg, 14 days, twice daily, 10 days, 6 weeks), and the numeric density denominator is 25 (word count including numeric words); thus, the numeric density is 5 of 15 (20%). The numeric complexity score is 2.5; 1 point each was given for the two medication doses ("take prednisone 10 mg daily for 14 days;" "take biaxin twice daily for 10 days"), and half a point was given for the use of a time frame ("return to clinic in 6 weeks").

Assessment of Readability of Instructions

Readability of the patient instructions was assessed using Microsoft Word grammar check, the FKRE, and the Flesch-Kincaid Grade Level (FKGL) test (Flesch, 1948). The FKGL test measures sentence length and number of syllables and is reliable, validated, and feasible to use (Kincaid, Fishburne, Rogers, & Chissom, 1875). The scoring system is embedded in Microsoft Word, making it a widely accessible test. The FKRE value provides a score between 0 (prac-

tically unreadable) and 100 (easy for any literate person). For health materials, an ideal index is between 60 and 70 (Souza et al., 2013). Use of shorter sentences and less complex words increases the score (Flesch, 1948; Friedman & Hoffman-Goetz, 2006; Wilson, 2009).

Coding Procedures

The coding of numeric information was completed independently by two of the investigators (C.P., R.G.). The inter-

coder agreement for the numeric complexity and numeric density scores were compared using the intraclass correlation coefficient (ICC). When the ICC was less than .95, discrepancies were resolved through discussion between team members.

Statistical Analysis

Summary statistics (means \pm standard deviations or frequencies and percentages) were used to describe the study population. The print health literacy skill of patients, measured with the S-TOFHLA, was categorized into groups: inadequate or marginal health literacy (<23) and adequate health literacy (\geq 23) (Baker et al, 1999). Numeracy skill, measured with the ANQ, was scored as the number correct on the four-item questionnaire with a potential range of 0 to 4.

Print health literacy demand of instructions, measured with the FKRE, was examined as a continuous variable (0-100). A two-sample independent *t*-test was used to compare the FKRE scores of those with inadequate or marginal health literacy to those with adequate health literacy.

Relationships between numeracy skills of the patient as measured by ANQ and demand of the print materials (complexity and density scores) were evaluated using Kruskal-Wallis tests. A *p* value \leq .05 was considered the threshold for statistical significance. All analyses were performed using SAS statistical software (version 9.4). Approval for both parent studies and this analysis were obtained from the University of Pennsylvania Institutional Review Board.

RESULTS

Study Population

A total of 317 unique participants from the parent studies had at least one medical appointment after January 1, 2010. Sixty-two participants did not have an appointment within the designated time frame; 33 had not had a print health literacy assessment, and 2 among these were deceased. Of the remaining 222 potential participants, the analysis of literacy demands compared to patient literacy skills was conducted on the 74 (33%) patients who were given personalized patient instructions in the AVS.

Participants were mostly African-American women (Table 2). Asthma morbidity was significant. Twenty-nine (39%) had an asthma-related emergency department visit in the year prior to enrollment and 16 (22%) had been hospitalized for asthma in that time interval. Comorbidities were prevalent (Table 2). Among the 74 participants, 55.4% (*n* = 41) had lower health numeracy (ANQ score of 0-2). According to S-TOFHLA scores, 9% (*n* = 7) had inadequate

PID	Participants Initials
Date	
EHR and Communication	
Patient Instructions:	
8/16/2010 : Allergy Ppme	
1) Continue Advair 500-50mcg 1 puffs twice a day. Rinse mouth after use.	
2) Use albuterol 90mcg 2 puffs 4-6 hours as needed.	
3) Budesonide 2 puffs inhaled twice daily. Rinse mouth after use.	
4) Continue Flonase 2 sprays per nostril twice daily.	
5) Continue Zyrtec 10mg daily.	
6) If asthma symptoms get worse, take Prednisone 40mg (8 tabs of 5 mg tabs) once a day. Call for further instructions.	
Please call with concerns or new or worsening symptoms. An allergist is always available 24 hours a day when the clinic is closed. Call and ask to speak with the allergy fellow on-call.	

Figure 3. This is an example of an After Visit Summary and calculation of numeric density and complexity scores (identifying data have been redacted). The numeric density numerator is 19, adding the numbers and indications of frequency (50-500 μ g, 1 puff, twice a day; 90 μ g, 2 puffs, 4-6 hours, 2 puffs, twice daily; 2 sprays, twice daily, 10 mg, 40 mg, 8 tablets, 5 mg tablets, once a day; call phone number, 24 hours) and 1 point given for enumerating the instructions with numbers, and the numeric density denominator is 106; thus, the numeric density score is 19 of 106 (17.9%). The numeric complexity score is 6.5 (6 medication doses provided at 1 point each and a half point for the use of a range [4-6 hours]).

or marginal health literacy (Table 3).

Numeracy Demand and Readability of Instructions

The median (range) of the total complexity score was 2.5 (0-46). The median (range) of scores for the coded domains of the complexity score were: Medication Dose, 1 (0-17); Self Adjustment of Medication (as in a tapered dose), 0 (0-2); General Goal Setting, 0 (0-9); Dates, 0 (0-3); Time Frame, 0.5 (0-3.5); and Numeric Symbols, 0 (0-29). Most instructions had at least one numeric component involving a medication dose (65%), and time frames not associated with dosing (59%). Almost one-third (26%) had a self-adjustment instruction. No instructions in the AVS contained numbers in the domains of Risk Outcomes or Goal Setting Requiring Calculations.

Examples of segments scored in the complexity measure are as follows: “Increase Medrol to 4 tablets a day for 3 days and then go back to 3 tablets a day” (Self Adjustment of Medication); “Wait 5-10 seconds—do not change your position or inhale, to allow the mist to settle” (Time Frame); “Optimal humidity level is 35%-40% (General Goal Setting); and “After 20% of your breath is inhaled administer a burst of medicine by depressing the delivery device” (Numeric Symbols). Higher numeric complexity score instructions often used a sequence of instructions about prescription and nonprescription medications, some of which require self-adjustment or a tapering dose (Figures 1-3). The median (range) in the AVS instructions of the frequen-

TABLE 2
Study Population (N = 74)

Characteristic	Mean (SD)
Age (years)	50 (13)
FEV1 (percent predicted)	67 (17)
BMI (kg/m ²)	32.2 (7.9)
	<i>n</i> (%)
Women	54 (73)
Race	
Black	49 (66)
White	20 (27)
Other ^a	5 (7)
Ethnicity: Hispanic/Latin	1 (1)
Household income <\$30,000/yr	45 (61)
Education (highest level achieved)	
Some high school	7 (9)
High school graduate	26 (35)
Some college	24 (24)
College graduate	31 (31)
Hospitalizations for asthma in past year	
0	58 (78)
1-2	7 (9)
>3	9 (12)
Number of ED visits for asthma in past year	
0	45 (61)
1-2	13 (18)
3 or more	16 (22)
Comorbidities	
Hypertension	39 (53)
Diabetes	13 (18)
Hyperlipidemia or high cholesterol	25 (35)
Other heart disease	3 (4)
Cancer	4 (5)
Instructions present by practice type	
Specialty	54 (79)
Primary Care	14 (21)

Note. BMI = body mass index; ED = emergency department; FEV1 = forced expiratory volume in 1 second; SD = standard deviation.

^aAmerican Indian/Alaskan Native, Asian, Native Hawaiian/Pacific Islander.

cy of words and numbers included within the AVS were 72 (12-748) and 6 (0-134), respectively. The median (range)

TABLE 3
Study Cohort (N = 74)
Health Literacy Skills

Cohort	<i>n</i> (%)
ANQ	
Number correct for each ANQ question	
Item 1 (arithmetic word problem-medication dosing)	55 (76)
Item 2 (simple percent, risk)	31 (43)
Item 3 (simple percent, peak flow meter)	53 (74)
Item 4 (interpretation of percent for peak flow meter)	25 (35)
STOFHLA	
Inadequate functional health literacy (score 0-16)	4 (5)
Marginal functional health literacy (score 17-22)	3 (4)
Adequate functional health literacy (score 23-36)	67 (91)

Note. ANQ = Asthma Numeracy Questionnaire (score range, 0-4); STOFHLA = Short Test of Functional Health Literacy in Adults (score range, 0-36, with a score of 23 or greater adequate).

numeric density score (numbers/words x 100%) was 8% (0%-33%). Thirty-six percent of instructions had more than 10 numeric occurrences. Forty-six percent of instructions had a density score more than 10%.

The median (range) of the ANQ was 2 (0-4). The median (range) of the FKRE was 57.5 (24.5-97.3). The median (range) of FKGL was 8.0 (1.4-19.5). Seventy-eight percent of instructions were written above a sixth-grade level.

Comparison of Patient Skills with Numeracy Demand and Readability of Instructions

The distribution of numeracy complexity and density stratified by level of asthma numeracy as measured by the ANQ is displayed in **Table 4** and in **Figures 4** and **5**. There was no association between level of asthma numeracy (ANQ) and numeracy demands of the patient instructions for either numeric density ($p = .81$) or numeric complexity ($p = .29$) as determined by the Kruskal-Wallis test. Further, there was no difference in FKRE scores (mean, standard deviation) between those with inadequate or marginal S-TOFHLA scores of less than 23 (FKRE: 49.8, 5.9) and those with adequate S-TOFHLA scores of 23 to 36 (FKRE: 58.8, 1.9) ($p = .16$).

TABLE 4

Distribution of AVS Numeric Complexity and Density Scores Stratified by the ANQ Score for the Patient Receiving the AVS

Numeracy (ANQ score)	Variable	n	Mean	Median	Minimum	Maximum	25th Percentile	75th Percentile
0	Complexity score	7	6.71	6.50	1.50	15.50	2.50	8.50
	Density score	7	8.44	7.82	2.50	14.04	3.40	13.79
1	Complexity score	21	4.71	2.50	0	26.00	1.00	6.50
	Density score	21	10.99	10.25	.20	26.60	3.70	15.38
2	Complexity score	13	2.81	2.00	0	11.50	.50	4.50
	Density score	13	8.17	7.70	0	21.66	5.20	9.75
3	Complexity score	13	6.46	2.50	0	46.00	1.00	6.50
	Density score	13	12.69	9.20	0	30.00	6.00	23.10
4	Complexity score	20	3.78	3.00	0	25.00	1.25	4.00
	Density score	20	8.63	6.44	1.90	21.40	3.77	13.05

Note. ANQ = Asthma Numeracy Questionnaire; AVS = After Visit Summary.

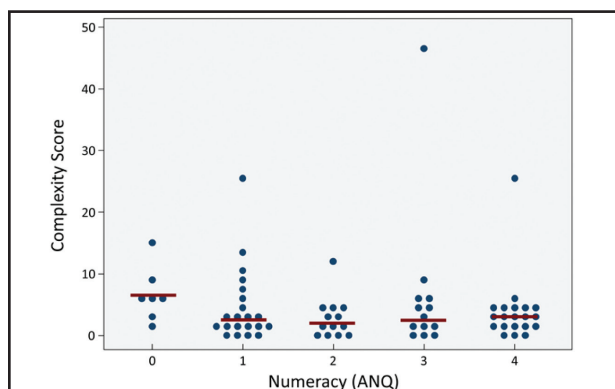


Figure 4. Distribution of After Visit Summary numeracy demand using the complexity score across five levels of Asthma Numeracy Questionnaire (ANQ) skill. Bars represent the median value. Numeric complexity was determined by identifying the domain of content numeric information used, applying a weight that reflects the complexity of that content, and determining a summary score for the document. The domains included were (1) medication dose, (2) self-adjustment of medication, (3) risk of outcomes, (4) general goal setting, (5) goal setting requiring a calculation, (6) dates, (7) time frame, and (8) numeric symbols.

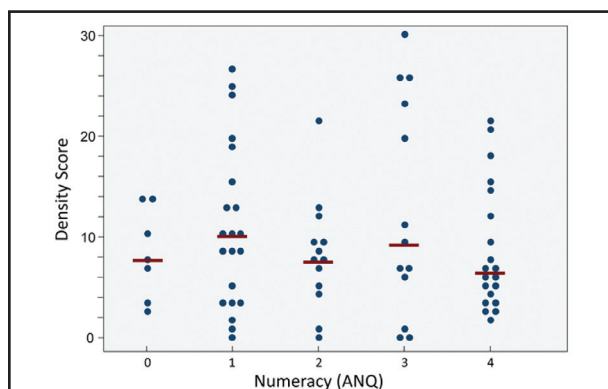


Figure 5. Distribution of After Visit Summary numeracy demand using the density score across five levels of Asthma Numeracy Questionnaire (ANQ) skill (ANQ). Bars represent the median value. The numeric density score was determined by dividing the frequency of numeric terms used by the number of words in the document.

DISCUSSION

In this study, we developed measures to assess the health numeracy demand of AVS instructions provided to patients with asthma through the EHR. We found patient instructions to contain a wide range of frequency and complexity of numeric information. However, we found no evidence of alignment between numeracy and print literacy demand of instructions with the skill level of individuals for whom the instructions were composed.

Lack of alignment between literacy demand and patient skill is especially important if the demand is higher than patient skill and patients are not able to understand and use the information provided. Numeric information, in particular, is essential for risk communication and instructions regarding medication management, including the self-adjustment of medication dosing. Self-adjustment of medications is not only important for patients with asthma but also for patients with other chronic diseases such as congestive heart failure and diabetes. As illustrated in the AVS examples provided (Figures 1-3), the numeracy demand (density and complexity scores) will increase as

more numeric information is provided. Numeric information (including medication dosing) is essential for patient self-management and highly valued by patients (Black et al., 2015). Therefore, the goal of measuring numeracy demand is not necessarily to reduce the amount of numeric information provided. Rather, awareness of high numeracy demand in AVS can alert clinicians to a potential communication barrier and prompt the use of strategies to improve understanding, such as plain language, avoiding unnecessary use of numeric symbols such as decimals and percentages, and use of the “teach back” technique. Primary care physicians notified of patients with a low health literacy level were found more likely to use recommended communication strategies (Seligman, et al., 2005). Knowledge of high numeracy demand in the AVS may similarly trigger the use of literacy-sensitive communication strategies (Hitchcock & Sanders, 2016).

High numeracy demands in the AVS are most likely to be a barrier to communication in patients with low health numeracy. Multiple measures are available to assess a patient’s health numeracy level (Apter et al., 2006; Baker et al, 1999; Parker, Baker, Williams, & Nurss, 1995; Lipkus, Samsa, & Rimer, 2001; Schapira et al., 2012; Johnson et al., 2013; Osborn et al., 2013; Weiss et al, 2005). Although universal approaches to clear communication is one strategy, screening for health numeracy and alerting clinicians when a patient has low health numeracy, especially when the numeracy demand of their AVS is high, is an alternative approach (Seligman, et al., 2005; Hamm, Bard, Hsieh, Stein, 2007). Whether universal or contingent approaches are used, measurement of the numeracy demand of patient materials provides valuable information to clinicians and health educators.

Efforts to evaluate the numeracy demand of patient materials have been applied in previous research. Joram et al. (2012) classified numeric concepts and reading level among 150 diabetic-related passages as basic, intermediate, or advanced based on the mathematical concepts required. This study identified the use of more advanced numerical concepts and higher reading demand in passages about diabetes prevention compared to other sections. Simonds, Rudd, Sequist, & Colditz (2011) also assessed numeracy demand of diabetes prevention education materials by counting the number of times numeric concepts were used in the materials. Although they found readability higher than recommended, numeric terms were not often used and numeracy demand was low (Simonds et al., 2011). Helitzer, Hollis, Cotner, & Oestreicher (2009) classified numeric content of cervical cancer prevention materials as not suitable, adequate, or superior with

respect to an optimal presentation for low-literacy populations. Common readability scores used, such as the FKRE test, do not incorporate numbers or attempt to assess numeracy demand (Wang, Miller, Schmitt, & Wen, 2013). Other readability tests, such as the New Dale-Chall Readability Formula (with a focus on the use of difficult vs. familiar words) or the Simple Measure of Gobbledygook, also do not assess numeracy demand (Rosenberg et al., 2016). Evaluation for use of plain language and use of the Suitability Assessment of Materials measure addresses domains for both print and numeric communication but do not lead to a quantifiable measure of the numeracy demand of patient materials (Hitchcock and Sanders, 2016; Howe, Barnes, Estrada, & Godinez, 2016).

Our approach to the assessment of numeracy demands is novel in encompassing both the density and complexity of the concepts being conveyed. Given the advent of meaningful use initiatives, where more integrated health systems are using patient portals as a secure and confidential web interface between patients and their health records, the ability to create practical measures of the numeracy demand of patient materials is increasingly feasible and important (Fox, 2011; Schickedanz et al., 2013). We recommend that both a numeracy demand measure and readability score be used to assess health literacy demand of patient materials.

This study does have some limitations. First, the study used new measures of numeracy demand. These measures demonstrated content and face validity. The validity of these measures must be further evaluated in larger cohort studies that can assess the association of numeracy demand scores with health outcomes including knowledge, confidence in knowledge, and health behavior. Second, readability formulas have been criticized for inaccuracy because they cannot measure items such as context, coherence of text, text that contain numbers, fragmented sentences, and text with bulleted lists (Wang, Miller, Schmitt, & Wen, 2013). The numeracy density score has similar limitations. The numeracy demand measures proposed do not assess best practices of risk communication such as the consistent use of time frame or assess key numeric information omitted in the AVS. Despite these limitations, the numeracy demand measures proposed have potential value. Computerized calculations of readability are advantageous because they decrease the possibility of human error and are standardized among all computers using common word-processing software. The numeracy density measures would provide a similar objective measure of numeric demand in patient educational materials. The numeracy complexity measure provides

greater context as scores are determined based on both the frequency and complexity of information provided. These measures, if further validated, could be adapted for use on software to assess the health numeracy demand of patient-information materials. Finally, our sample was limited to patients in one health system and with a diagnosis of moderate-to-severe asthma who attended an outpatient clinic, but asthma is a common condition associated with significant morbidity and an important target condition for comprehensible health education and instructions (Centers for Disease Control and Prevention, 2011). Further studies could expand the generalizability of our findings across health care systems and to other chronic and acute conditions.

CONCLUSION

We report the development of health numeracy demand measures that encompass both frequency and complexity of numeric concepts conveyed in the context of patient instructions about chronic disease management. We find a lack of alignment between the numeracy demand of materials and the patient level of health numeracy, raising concerns regarding the ability of patients to process and apply the more complex information provided. As more patients obtain information through the EHR via AVS and the patient portal, it is critical that health care providers give numbers and numeric concepts in a way that patients are able to use effectively in caring for their health.

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