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HEALTH LITERACY AND PRESCRIPTION DRUG ADHERENCE AMONG ELDERLY TYPE TWO DIABETICS

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ABSTRACT

Health literacy problems and low medication adherence are significant issues in the United States and have been linked to negative outcomes (Berkman et al., 2011). Health literacy is "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (Nielsen-Bohlman et al., 2004). Medication adherence is the level to which a patient takes their medication as prescribed by their healthcare provider (Lesen, 2011). The purpose of this study is to determine whether health literacy is related to medication adherence levels of elderly Type II diabetics in Pennsylvania. The data examined were obtained from the Pennsylvania Assistance Contract for the Elderly (PACE), a state-funded program providing pharmaceutical assistance to lower-income elderly persons. Pharmaceutical claims data and survey data on health literacy were provided for the 20,761 elderly applicants that met this study's main criteria. All study subjects were community dwelling elderly aged 65 or older who were using medications for Type II diabetes. The results show significant associations of literacy with demographic factors, with higher likelihood of literacy problems being found in older age groups, Hispanics, and males. The results of this study also indicate that literacy, as well as demographic factors, are significant associated with non-adherence. Elderly who reported any literacy problems were more likely than those without literacy issues to demonstrate poor adherence to antidiabetic therapy. Although further research is needed, the results suggest that intervention efforts to improve medication literacy among older diabetics may have a bearing on medication adherence and adherence-related diabetes outcomes.

TABLE OF CONTENTS

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Introduction

Literacy and Health Literacy.

According to the 2003 National Assessment of Adult Literacy (NAAL), literacy is the ability to use "printed and written information to function in society, to achieve one's goals, and to develop one's knowledge and potential" (Kutner, et al., 2006). Literacy includes understanding and applying written materials to accomplish daily tasks. Millions of Americans, and especially older Americans, do not have basic literacy skills. According to preliminary estimates based on the 2003 NAAL, 14% of adults (age 16 and older) and 26% of older adults (age 65 and above) have "Below Basic" levels of ability to read prose literature.

There are also concerns that problems in basic literacy are compounded when dealing with health care information. A recent report from the Institute of Medicine defines health literacy as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (Nielsen-Bohlman et al., 2004). Health information, as defined in the report, could include procedure consent forms, appointment schedules, medication instructions, and oral or written information from health care providers. Health literacy is a person's ability to understand and use healthcare information to make any decision in regards to their health, as well as the ability to appropriately adhere to medical instructions. Health literacy requires a number of different skills including basic skills in reading and understanding health information, discussing the written information with health care providers, and even quantitative competence (Berkman et al., 2011).

Health literacy is now widely recognized as an important component of a wide range of health-related activities, including health promotion and health maintenance. Each year it is estimated that as much as $73 billion in unnecessary health services are expended due to adverse

consequences attributable to health literacy problems (National Academy on an Aging Society, 1998). Health literacy problems may also be a factor in adherence and non-adherence to drug and behavioral therapies for many diseases, including diabetes (American Medical Association, 1999).

Currently, low health literacy is a major health problem in the United States. As of 2003, over 80 million (36%) American adults were considered that have limited health literacy, which is about 36 percent of the population (Berkman et al., 2011). Poor health literacy is especially common in the elderly, in minority groups, and in patients with one or more chronic condition (Schillinger et al., 2002). Also, low health literacy has been associated with adults whose primary or "first" language is not English and with persons who live below the poverty line (Berkman et al., 2011).

In 2004, a systematic evidence review by the Society of General Internal Medicine found that poor health literacy and adverse health outcomes were related (Berkman et al., 2011). Poor outcomes due to low health literacy levels can be from a large variety of misunderstanding. For example, patients may not understand how to interpret prescription drug labels, which may lead them to not take their medication properly (Schillinger et al., 2002). Also, they may not comprehend the severity of their health condition or how to manage it, which can lead to them not following their treatment plan.

Another way poor health literacy can lead to poor outcomes is when patients fail to communicate all vital information in regards to their treatment to the correct healthcare provider. For example, they may fail to inform their healthcare providers of all the medications they are taking or not report any negative side effects from the prescribed drugs they are given (Schillinger et al., 2002). In fact, they may not even be able to name all of the medications that

they are taking. They also may not feel comfortable informing their healthcare provider that a treatment may go against their healthcare beliefs or even their cultural or religious beliefs (Schillinger et al., 2002).

Low health literacy has a large impact on a patient's health behaviors. If the patient does not understand how or why adhering to their treatment is important, their condition may worsen and can even lead to death in certain cases. In a society where self-management is becoming more common, low health literacy may be the barrier that is keeping patients from adhering to their prescription drugs and treatments (Schillinger et al., 2002). For chronic diseases, such as Type II diabetes, self-management of the condition allows patients to live their lives but if they fail to adhere to the required medications, the outcome could be fatal.

Medication Adherence.

Medication adherence is the level to which a patient takes their medication as prescribed by their healthcare provider (Lesen, 2011). Studies have shown that patients with chronic conditions are on average only 50 percent adherent to prescribed treatments (Lesen, 2011), with the average patient adherence in Type II diabetes averaging 67.5 percent (Pladeval, 2004).

Poor adherence has been associated with both negative health outcomes and increased healthcare costs (Lesen, 2011). Adverse health outcomes associated with poor adherence include complications from the condition, disease progression, avoidable hospitalizations, and both premature disability and death (Pladeval, 2004). It is estimated that avoidable healthcare costs due to poor medication adherence accumulate to $100 billion per year (Pladeval, 2004).

Understanding how to help patients adhere to their prescription drugs is important in the management of chronic diseases and will help reduce the associated negative outcomes.

Diabetes and Medication Use.

Diabetes mellitus is a chronic, metabolic disorder where the body does not produce enough insulin, cells no longer respond to insulin or it is a combination of both defects (American Diabetes Association [ADA], 2012). Currently, there are over 346 million people with diabetes across the world and 25.8 million of these diabetics are in the United States alone (World Health Organization [WHO], 2012; National Institutes of Health [NIH], 2011). There are several types of diabetes that are commonly recognized, Type I, Type II, and Gestational. Type I diabetes is the less common of the two types and usually begins to develop in childhood or adolescence, requiring lifelong treatment of insulin injections (WHO, 2012). Type II diabetes develops later on in life; over 90 percent of diabetics are considered to have this type of the disorder (WHO, 2012). Gestational diabetes occurs when a pregnant woman is no longer able to make or use the insulin needed for pregnancy which leads to high levels of glucose in the body (ADA, 2012).

Of the 8.3% of Americans that have been diagnosed with diabetes, between 90 and 95 percent have Type II diabetes (NIH, 2011). Type II diabetes develops when a person's body becomes insulin resistant and blood sugar can no longer be stored in the body's cells (WHO, 2012). This leads to hyperglycemia, or excess sugar in the blood, which can cause immense fatigue, thirst, urination, and weight loss (ADA, 2012). Long-term symptoms are more severe and complications due to damage in the eyes and kidneys, infected ulcers, and nerve damage can lead to permanent blindness, renal failure, and leg amputation (WHO, 2012). Type II diabetes is more common in the elderly and approximately 18 percent of people over the age of 65 years old have this condition (Schillinger et al., 2002).

According to the World Health Organization, it is expected that the number of deaths related to diabetes, which is currently about 3.4 million, will double by the year 2030 (WHO, 2012). With such a drastic increase, it is important to research why the mortality rates for diabetes are increasing across the world and what the underlying factors are.

In Type II diabetes, patients are in most cases required to take multiple drugs to control the symptoms of hyperglycemia and the adverse effects of uncontrolled hyperglycemia (Grant, 2003). The first treatment step for Type II diabetes is to make life style changes such as meal planning, weight loss and exercise to help lower the patients' blood glucose levels (ADA, 2012). When this does not work, the next step is to take oral medications.

There are multiple types of oral medications options that are taken to lower blood glucose levels in Type II diabetics. And many of these oral medications are used in combination pills. Acarbose and miglitol are alpha-glucosidase inhibitors that slow the digestion of carbohydrates in order to lower you blood glucose levels but they can lead to gas, bloating, and diarrhea (ADA, 2012). Metformin, a biguanide, comes in three different strengths and it acts by lowering glucose production while increasing glucose uptake (ADA, 2012). Bromocriptine is a dopamine agonist that lowers blood sugar levels by an unknown mechanism and the side effects include nausea, vomiting, dizziness and headache (ADA, 2012). Sitagliptin, saxagliptin, and linagliptin are all DPP-4 inhibitors that increase the level of insulin in the patient's body after a meal (ADA, 2012). Nateglinide and repaglinide are meglitinides that increase the production on insulin by the pancreas (ADA, 2012). The largest oral drug category is the sulfonylureas which includes glimepiride, glipizide, glyburide, chlorpropamide, tolbutamide, and tolazamide (ADA, 2012). All of these drugs work to increase the production and release of insulin by the pancreas.

Thiazolidinefiones (TZDs), examples of which are pioglitazone and rosiglitazone, help to decrease muscle and liver insulin resistance (ADA, 2012).

Another treatment option is insulin injection. Insulin, a hormone secreted from the pancreas, is often prescribed to Type II diabetics because their bodies can no longer use insulin properly (ADA, 2012). Each patient is unique in the strength and frequency that they will need an injection. There are five categories of insulin available; rapid-acting, regular, intermediate-acting, long-acting and mixture options (ADA, 2012).

Other injectable medication options, aside from insulin, are available. Byetta (exenatide) increases insulin secretion and decreases the amount of glucose in the blood but this drug leads to nausea and vomiting (ADA, 2012). Symlin (pramlintide acetate) lowers both the patient's appetite and the blood glucose levels in the body after a meal but it cannot be mixed with insulin (ADA, 2012). A third agent, Victoza (liraglutide), increases the production of insulin in the body but can lead to side effects such as acute pancreatitis (ADA, 2012).

Adherence to Diabetes Medications, and Literacy Problems.

Adherence to medications for diabetes, despite the uncomfortable side effects, is very important to help prevent such negative outcomes. Diabetic patients on average have very high treatment adherence but many have some problems being adherent to one or more medications (Grant, 2003). Nonadherence in diabetic patients has been reported when they experience negative side effects from a prescribed medication and when the patient believes the medication is ineffective (Grant, 2003). Overall, it is important for the patient to understand that the medications prescribed for diabetes care does help to manage the patient's chronic condition. Lack of understanding can lead to nonadherence and adverse sequelae associated with nonadherence. Uncontrolled diabetes can have serious adverse effects. For example, something

as simple as an undetected foot ulcer can lead to infection and later, the need for amputation of one or more toes, a foot, or even a leg. When diabetics are adherent to their prescription drugs and know to constantly check their blood levels as well as for complications such as foot ulcers, their chances for negative outcomes decrease (ADA, 2012). This shows the need for diabetic patients to take their diabetes medications and the underlying need to understand why adhering to their prescriptions is important and how to do so properly.

The purpose of this study is to examine--in an elderly sample of diabetes medication users--the prevalence of health literacy problems, the prevalence of diabetes medication nonadherence, and the association of literacy problems with nonadherence in a sample of elderly users of antidiabetic medications.

Methods

Source of Data.

The data for this study were provided by the Pharmaceutical Assistance Contract for the Elderly (PACE). PACE, administered under the Pennsylvania Department of Aging, is a limited pharmaceutical assistance program for Pennsylvania residents aged 65 and older who meet certain income requirements. PACE provides coverage for all prescription drugs as well as insulin, insulin syringes, and insulin needles. In 2005, the annual eligibility income for participants could not exceed $17,200 for married couples and $14,000 for single, widowed or divorced individuals. Enrollees in the PACE Extended Tier (PACENET) program were also eligible. Enrollees in this program must meet the same age and Pennsylvania residency requirements as PACE participants, but the income can range from $17,200 and $19,200 for married couples, and between $14,000 and $16,000 for single elderly persons.

Demographic Data. All PACE applicants complete a detailed application form prior to enrollment. This application form includes information on age, gender, marital status, and other demographic factors used in this study. Depending on their income, PACE enrollees were required to reapply either annually or biannually to the PACE program during the time period used for this study.

Medication Data. Each time a prescription medication that has been ordered by a licensed physician and dispensed by a licensed pharmacist is purchased by a PACE cardholder, a separate prescription claim is generated in the PACE database. The information on the claims database includes the date that the drug is dispensed, the nature of the drug dispensed (e.g., an antidiabetic), the time period for the prescription (e.g., the "days supply"), and dosing

information (e.g., number of tablets or other units dispensed). These data allow the computation of the measures of adherence (see *Adherence Measures* below) used in this study.

Health Literacy Data. For purposes of research and program evaluation, PACE includes an optional two-page survey--the *Survey on Health and Well-Being*--with all new and renewal enrollment applications. This optional survey includes information on a variety of topics. This survey is the source of data relating to literacy problems that were used in this study. Instructions accompanying the survey include assurances of confidentiality and explain that completion of the survey is voluntary and will not affect PACE coverage. Historical data suggest that most PACE cardholders view the survey positively, with annual response rates exceeding 70%.

All data used for this study were obtained under the auspices of the Medication, Health, and Aging Program, a research program under the leadership of Dr. Frank Ahern, of the Department of Biobehavioral Health, Penn State University. The data used in this study were acquired for research studies that are currently approved by the Institutional Review Board of the Pennsylvania State University.

Subjects.

For this study, data were needed for PACE enrolled persons who: 1) were users of antidiabetic drugs commonly prescribed for Type II diabetes; 2) had completed the survey questions on health literacy (see below); and 3) were not living in a nursing home. Using these criteria, pharmaceutical claims data and survey data on health literacy were available for 20,761 elderly PACE-enrolled elderly.

Measures.

Demographic Characteristics. Data were available for age, sex, race, and marital status. The mean age of this sample of elderly was 76.35 years with a range of 65 to 103. For this study, actual age was recoded as a categorical variable as follows: 65-69, 70-74, 75-79, 80-84, and 85 and above (85+). Upon examination of the number of subjects for specific race categories reported, it was determined that insufficient data were available for some race categories (e.g., American Indians/Alaska Natives, Pacific Islanders) and therefore for this study race was recoded as White, Black, Hispanic, and Other. The PACE application form allows beneficiaries to describe their marital status as single, married, married living separately, divorced, or widowed. The married living separately category applies to spousal pairs in which one member may be living in a nursing home. Again, because insufficient data were available for some categories (e.g., married living separately, divorced) for this study, marital status was recoded as a dichotomous categorical variable coded as Married (including married and married living separately) and Not Married (single, divorced, or widowed).

Adherence. Refill adherence was measured by using the Continuous Measure of Medication Acquisition (CMA) according to the procedures described by Steiner and Prochaska (1997). The CMA is computed by examining the prescription drug refill behavior of the PACE beneficiary. In the PACE program prescriptions for drugs used on a chronic basis are usually filled with enough medication to last for 30 days (the "days-supply"). Refills are allowed before the days-supply is exhausted. Using the dates of refills and the days-supply it is possible to infer adherence over a period of time. Elderly who do not obtain a refill before their days-supply is exhausted are thought to be nonadherent or not taking their medication according to the physician's orders. Elderly who refill their prescriptions before the days-supply is exhausted are

assumed to be adherent. In this study refill behavior was examined for a period was 365 days. If the beneficiary refills the medication regularly there will be available medication for the full period that is being examined. The following equation was used to compute the Continuous Measure of Medication Acquisition (CMA):

$$\text{CMA} = \frac{\text{Total Days-Supply of Antidiabetic Medications}}{\text{Number of Days in Observation Period}}$$

This CMA measure provides the percentage of the days for which the beneficiary had available medications. The raw CMA measure ranges from fully adherent (100%) to fully non-adherent (0.0%). By convention, the minimum CMA for adequate medication adherence is considered to be 80% (Lesen, 2011). A CMA lower than 0.80 is considered poor adherence and is associated with increased risks for adverse outcomes (Lesen, 2011). For this study elderly users of antidiabetic medications were defined as Adherent if the computed CMA was at or above 80%, and Nonadherent if below 80%.

Health Literacy. Health literacy was assessed by asking PACE beneficiaries questions on the *Survey on Health and Well-Being* relating to problems regarding reading and understanding medication-related information. The following questions were used:

Do you have any problems reading or understanding instructions about your medications that you receive from your physician or pharmacist?

1. *No, I have no problems reading and understanding instructions about my medications.*
2. *Yes, Sometimes I do have problems.*

    If yes, what kinds of problems do you have? Please check all that apply:

    a. *Vision problems (for example, reading, small print)*
    b. *Problems in reading (for example understanding words)*
    c. *Problems because English is not my native language*
    d. *Other problems (please describe briefly)*_____

For this study, the data on health literacy problems were recoded as a summary dichotomous variable, Any Health Literacy Problem, as "Yes", if any problem was mentioned (a, b, c, d) and "No", if otherwise.

Statistical Analyses.

Cross tabulations with Chi-square analyses were used to examine the association of the dichotomous measure of Any Health Literacy Problems, and the dichotomous measure of Adherence with demographic factors. Multivariate Logistic Regression analysis was used to examine the association of adherence with literacy problems and demographic factors. Logistic Regression (LR) is a technique that is more appropriate than ordinary least squares (OLS) regression when the dependent variable is binary. The dependent variable in logistic regression analysis is typically the log of the event odds – or logit -- with the event odds reflecting the probability of the event occurring divided by the probability of the event not occurring (probability/(1-probability). For the present study, the event of interest is the outcome of non-adherence, and each of the independent predictor variables (sex, race group, age group, marital status, and the indicator variable of reporting one or more health literacy problems) are coded using dichotomous variables. When the dependent variable and predictor variable are both dichotomous, the odds ratio reflects the probability that the dependent variable is coded as non-adherent (coded as 1) when the predictor is also coded as 1 (e.g., males), compared to the probability of nonadherence when the predictor is 0 (e.g., females). When the independent predictor has no effect, the event odds associated with both levels of the predictor variable are equal, and the expected value of the odds ratio is therefore 1.0. In practice, one of the dichotomously coded groups is the reference group (coded as 0) and the odds ratio for that group is by definition equal to 1.0. In multivariate logistic regression the odds ratio for each

independent variable represents the effect of that variable after statistically controlling for all other variables in the equation.

Results

Demographic Characteristics of Sample.

Table 1 displays descriptive statistics of the study subjects (N=20,261) that met the inclusion and exclusion criteria for the study. For this sample there is a significantly greater proportion of females (74.8%) as compared to males (24.2%). The sample is predominantly White (89.1%), and Not Married (73.1%). The distributions by sex, race, age, and marital status observed for this study sample are similar to that of the total population of PACE enrolled. However, it should be noted that the PACE population from which the sample was drawn is not representative of all persons age 65 and above in the general U.S. population. PACE is a prescription drug benefit program for lower income elderly, with elderly in the oldest age groups being more likely than younger elderly to qualify for the program. Thus PACE enrolled elderly are generally older than the general population. In addition, because elderly females--especially elderly widowed females--are more likely to have lower incomes and because women live longer than men on average, the PACE population includes a greater representation of elderly females, compared with the general elderly population.

Table 1. Demographic Characteristics of Study Subjects

	Study Sample *(n = 20,261)*	
Variable	***n***	**%**
Sex		
Male	5,227	25.2
Female	15,534	74.8
Race		
White	18,510	89.2
Black	1,687	8.1
Hispanic	232	1.1
Other	332	1.6
Age		
65-69	3,801	18.3
70-74	4,798	23.1
75-79	5,390	26.0
80-84	4,244	20.4
85 +	2,528	12.2
Marital Status		
Married	5,592	26.9
Not Married	15,169	73.1

Demographic Characteristics and Health Literacy.

Table 2 presents the number and percent of responses for the questions in the *Health and Well-being Survey* on health literacy for the study subjects. Over 80% of the subjects did not report any type of literacy problem. Of the 18.9% of the subjects that reported having at least one health literacy problem, 18.2% indicated that they had vision problems. Reading was reported as a literacy problem for 5.9% of the subjects, and English as a language was a literacy problem for 1.6% of the subjects. An additional 4.8% of the subjects reported having at least one other health literacy problem aside from the three listed as options. In aggregate, nearly 4000 of the study subjects (18.9%) reported one or more health literacy problems.

Table 2. Reported Health Literacy Problems of Study Subjects

	Study Sample *(n = 20,261)*	
Variable	***n***	**%**
Survey Question 6 (quest6)		
Do you have any problems reading or understanding Rx instructions?		
a. Yes, Vision Problem	3,787	18.2
b. Yes, Reading Problem	1,208	5.8
c. Yes, English Language Problem	323	1.6
d. Yes, Other Problem	993	4.8
Any Health Literacy Problems (a-d)		
Yes	3,917	18.9
No	16,844	81.1

Table 3 describes the association of the dichotomous measure of Any Health Literacy Problem according to demographic characteristics of the sample. These results show that health literacy problems were significantly associated with sex ($X^2 = 18.0$, df = 1 $p < .001$) and were more likely to be reported by males (20.9%) as compared to females (18.2%). Reports of health literacy problems were also significantly associated with race ($X^2 = 104.3$, df = 3, $p < .001$) with 42% of the Hispanic subjects reporting one or more of the specific health literacy problems, compared to 22.3% of both the Black and Other racial groups and 18.2% of the White subjects. Reports of health-literacy problems were positively and significantly associated with age ($X^2 = 556.1$, df = 4 $p < .001$) with 13.8%, 14.2%, 16.7%, 22.5%, and 33.9% of the subjects reporting one or more problems for the ages groups 65-69, 70-74, 75-79, 80-84, and 85+, respectively. Reports of health literacy problems were not significantly associated with marital status ($X^2 = 0.36$, df = 1, $p=0.55$).

Table 3. Demographic Characteristics and Health Literacy

	Literacy Problems				
	No		*Yes*		
Variable	***n***	**%**	***n***	**%**	**X^2 ,df, prob**
Sex					
Male	4,137	79.1	1,090	20.9	18.0, df = 1, p <.001
Female	12,707	81.8	2,827	18.2	
Race					
White	15,142	81.8	3,368	18.2	104.1, df = 3, p <.001
Black	1,310	77.7	377	22.3	
Hispanic	134	57.8	98	42.2	
Other	258	77.7	74	22.3	
Age					
65-69	3,278	86.2	523	13.8	556.1, df = 4, p <.001
70-74	4,116	85.8	682	14.2	
75-79	4,488	83.3	902	16.7	
80-84	3,290	77.5	954	22.5	
85+	1,672	66.1	856	33.9	
Marital Status					
Married	4552	21.9	1,040	5.0	0.362, df=1, p=0.55
Not married	12,292	59.2	2,877	13.9	

Table 4. Results of Logistic Regression Predicting Any Health Literacy Problem from Demographic Factors

Variable	Odds Ratio	p-value	95% C.I.	
			Lower	Upper
Gender				
Male	1.000			
Female	0.810	<0.001	0.744	0.882
Race				
White	1.000			
Black	1.424	<0.001	1.259	1.610
Hispanic	4.053	<0.001	3.099	5.300
Other	1.465	0.005	1.123	1.912
Age				
65-69	1.000			
70-74	1.082	0.215	0.955	1.224
75-79	1.365	<0.001	1.212	1.537
80-84	2.028	<0.001	1.799	2.287
85+	3.657	<0.001	3.218	4.156
Marital Status				
Married	1.000			
Not Married	0.895	0.014	0.820	0.977

Table 4 shows the results of logistic regression predicting Any Health Literacy Problem from demographic factors. Whereas the results in Table 3 show the bivariate associations between demographic factors and health literacy, the results in Table 4 show the independent effects of each of the demographic factors, while controlling for all other demographic factors in the model. The results shown in Table 4 indicate that, when the demographic factors are considered together, each factor is significantly related to reports of having one or more health literacy problems. The results in Table 4 indicate that, in this sample of elderly users of antidiabetic medications, and controlling for age, race, and marital status, females are less likely to be reporters of literacy problems than are males. More specifically, the adjusted odds of reporting any health literacy problems is 0.81 if the elderly user of antidiabetic medications was

female compared to the odds of reporting any health literacy problem if the user was female, after controlling for race, age, and marital status. Racial and ethnic group differences are also apparent, with Hispanics being four times as likely as Whites to report any medication literacy issue. The likelihood of reporting medication literacy issues also varied by age, with higher age groups being more likely than those aged 65-69 to have literacy problems, controlling for other factors in the model.

Demographic Characteristics and Medication Adherence.

Table 5 displays the prevalence of the recoded dichotomous measure of adherence for the study subjects. Of the 20,261 elderly users of antidiabetic medications users in the study sample, 71.7% were considered to be adherent with a CMA of at least 80%, and 28.3% had a CMA under 80% and were therefore considered nonadherent.

Table 5. Adherence Levels of Study Subjects

	Study Sample *(n = 20,261)*	
Variable	***n***	**%**
CMA at least 80%		
Yes (Adherent)	14,882	71.7
No (Nonadherent)	5,879	28.3

Table 6 displays the association of adherence to antidiabetic medications with demographic characteristics and with medication literacy. Nonadherence was significantly associated with sex ($X^2 = 5.1$, df = 1, $p < .001$) with 29.5% of males being nonadherent compared to 27.9% of the females. Nonadherence was also significantly associated with race ($X^2 = 272.4$, df=3, $p < .001$). Among elderly users of antidiabetic medications the prevalence of nonadherence was highest among Hispanics (47.8%) followed by Blacks (43.3%), Others (37.7%) and Whites

(26.5%). Nonadherence was also associated with age ($X^2 = 32.0$, df = 4, p <.001) but although the variability in prevalence across age groups was not great, there was an obvious age gradient in nonadherence with the youngest category of elderly users of antidiabetic medications being more nonadherent (30%) as compared to the oldest age group for which the prevalence of nonadherence was 24.3%. The bivariate results shown in Table 6 also indicate that nonadherence was significantly associated with health literacy problems, with those reporting any literacy issue being more likely to be nonadherent ($X^2 = 8.444$, df =1, p<.004)

Table 6. Demographic Characteristics and Medication Adherence

CMA at least 80%:	**No (Nonadherent)**		**Yes (Adherent)**		
Variable	***n***	**%**	***n***	**%**	**X^2, df, prob**
Sex					
Male	1,544	29.5	3,683	70.5	5.1, df = 1, p <.001
Female	4,335	27.9	11,199	72.1	
Race					
White	4,913	26.5	13,597	73.5	272.4, df = 3, p <.001
Black	730	43.3	957	56.7	
Hispanic	111	47.8	121	52.2	
Other	125	37.7	207	62.3	
Age					
65-69	1,140	30.0	2,661	70.0	32.0, df = 4, p <.001
70-74	1,424	29.7	3,374	70.3	
75-79	1,543	28.6	3,847	71.4	
80-84	1,157	27.3	3,087	72.7	
85 +	615	24.3	1,913	75.7	
Marital Status					
Married	1,572	28.1	4, 020	71.9	0.160, df = 1, p=0.69
Not Married	4,307	28.4	10,862	71.6	
Literacy Problems					
No	4,696	27.9	12,148	72.1	8.444, df =1, p<.004
Yes	1,183	30.2	2,734	69.8	

Table 7. Results of Logistic Regression Predicting Medication Non-Adherence from Literacy and Demographic Factors

Variable		Odds Ratio	p-value	95% C.I.	
				Lower	Upper
Gender					
	Male	1.000			
	Female	0.934	0.070	0.868	1.006
Race					
	White	1.000			
	Black	2.072	<0.001	1.870	2.295
	Hispanic	2.359	<0.001	1.816	3.065
	Other	1.627	<0.001	1.299	2.038
Age					
	65-69	1.000			
	70-74	1.001	0.979	0.911	1.100
	75-79	0.965	0.445	0.879	1.058
	80-84	0.906	0.052	0.820	1.001
	85+	0.770	<0.001	0.684	0.867
Marital Status					
	Married	1.000			
	Not Married	1.042	0.272	0.968	1.123
Literacy Problems					
	No	1.000			
	Yes	1.119	0.005	1.034	1.210

The Relationship of Health Literacy with Medication Adherence.

Table 7 shows the prediction of medication adherence from literacy and demographic factors. The odds ratio of males in comparison to females was 1.057. In comparison to White subjects, the odds ratios of the other subjects were 0.480 for the Black subjects, 0.424 for the Hispanic subjects, and 0.616 for the other subjects. For the age groups, all of the subjects had an odd ratio at around 1.000. In comparison to the 65-69 age range, the 70-74 group had an odds ratio of 0.997, the 75-79 group had an odds ratio of 1.032, the 80-84 group had an odds ratio of 1.096, and the subjects of 85 years had an odds ratio of 1.285. For the health literacy prediction

of medication adherence, those who did not report any health literacy problems had an odds ratio of 0.895 in comparison to the subjects who reported at any literacy problems.

Discussion

Currently, millions of Americans have chronic diseases such as Type II diabetes. Keeping up with treatment plans and prescription drugs is especially difficult with these long-term conditions. This study examined if low health literacy predicted poor medication adherence in Type II diabetic patients as well as at the demographic characteristics that are associated with both. The overall purpose of this study was to determine whether health literacy is related to medication adherence levels of elderly Type II diabetics in Pennsylvania.

Of the 20,261 subjects, only 3,917 of them, or 18.9%, reported some type of literacy issue. There were other literacy issues reported, but vision problems made up the majority of literacy issues with 3,787 or 18.2% of the subject reporting that they had such problems. Of the subjects with reported literacy problems, males showed a higher risk for health literacy problems than the females. In fact, being female acted as a protective factor for health literacy issues. Also, the Hispanic study subjects had the highest risk for literacy problems at 42.2% and Black and other subjects showed a higher risk that White subjects. The subjects over the age of 85 years old were the most likely to have health literacy issues and the risk decreased with age. Overall, the group with the highest risk for literacy problems was Hispanic males over the age of 85 years old.

When looking at medication adherence levels, 5,879 or 28.3% of the 20,261 study subjects were considered to have poor medication adherence because their CMA levels were below 80%. Males were more likely than females to have poor medication adherence and the being female again acted as a protective factor. The highest adherence issues were found in the Hispanic subjects, followed by the Black subjects, other subjects, and then the White subjects. Low adherence decreased with age seeing that the 65-69 age group had the largest proportion of

subjected with low medication adherence and the subjects over the age of 85 years had the smallest proportion of subjects with adherence issues.

Overall, more subjects had medication adherence issues than literacy problems. Also, adherence issues decreased with age as health literacy issues increased with age. Hispanics had the highest non-adherence and poor health literacy out of all of the racial groups, followed by the Black subjects and then the other subjects. The White subjects showed the highest literacy and adherence to medication. And males had more issues with prescription drug adherence and literacy than the female subjects.

The results of this study agree with the idea that lower health literacy and poor medication adherence are related in elderly diabetic patients. Only a small proportion of the study subjects showed low health literacy but the majority of study subjects with low health literacy also had poor medication adherence to their Type II diabetes prescription drugs. This study leaves behind the question of whether or not the study subjects who had both low health literacy and poor prescription drug adherence also had poor health outcomes as a result of the non-adherence.

Limitations

There were multiple limitations within this study. One limitation of this study was the absence of health outcomes in regards to the Type II diabetic patients. These data would be beneficial in researching the outcomes of low health literacy and poor medication adherence.

A second limitation is that all of the subjects were enrolled in the Pennsylvania PACE program and were not representative of all U.S. elderly. In particular, the sample is skewed towards White older females. The prescription drug adherence and health literacy of these subjects may differ in comparison to other elderly Type II diabetics in different environments.

Another study limitation is that the literacy problem variable may be confounded with the problem of visual acuity. Vision problems are common in the elderly, which might not be controlled for by including age in the logistic regression results. Although vision problems may affect a person's ability to read and understand medication label instructions, it may be more appropriate to examine vision and other dimensions of medication literacy as separate domains.

Future Directions

Further research is needed to determine the connection between health literacy and medication adherence. Many patients suffering from chronic conditions have poor prescription drug adherence, placing them at risk for poor outcomes. Future research in understanding how to increase the health literacy and medication adherence in these patients would be beneficial. More research is also needed to understand if an increase in health literacy leads to better diabetes medication adherence and improved outcomes. And lastly, future studies may consider re-defining any Literacy Problem in order to exclude the vision problems from the analysis.

Conclusions

In conclusion, this study found significant associations between health literacy and medication adherence among elderly subjects enrolled in PACE. Persons with any medication literacy problem were 12% more likely than those with no literacy problems to have poor medication adherence. Other factors, including gender and race, were also associated with both literacy and adherence. Hispanic elderly men had the lowest medication adherence and health literacy of all study groups. Future intervention efforts should focus on ways to improve elderly individuals' understanding of their diabetes treatment regimens and medication instructions.

Further research is also needed to understand the specific dimensions of health literacy and which literacy dimensions are most instrumental in medication adherence.

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HONORS & AWARDS

Student Leadership Scholarship (2009, 2011)

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WORK & RESEARCH EXPERIENCE

PACE/PACENET Research, Pennsylvania Department of Aging (September 2011-Present)

- Researching health literacy and medical adherence of elderly Type 2 diabetics under the supervision of Dr. Frank Ahern.

Patient Navigation Interview Project, Penn State Hershey (Fall 2010)

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