ELSEVIER

Patient Education and Counseling 67 (2007) 293–300

Patient Education and Counseling

www.elsevier.com/locate/pateducou

# To err is human: Patient misinterpretations of prescription drug label instructions

Michael S. Wolf [a,b,e,*], Terry C. Davis [c], William Shrank [d], David N. Rapp [a,e,f], Pat F. Bass [c], Ulla M. Connor [g], Marla Clayman [b], Ruth M. Parker [h]

[a] *Health Literacy and Learning Program, Institute for Healthcare Studies, Northwestern University, United States*
[b] *Center for Communication and Medicine, Division of General Internal Medicine, Northwestern University, United States*
[c] *Louisiana State University Health Sciences Center at Shreveport, United States*
[d] *Brigham and Women's Hospital and Harvard Medical School, Boston, MA, United States*
[e] *School of Education and Social Policy, Northwestern University, United States*
[f] *Department of Psychology, Northwestern University, United States*
[g] *Indiana Center for Intercultural Communication, Indiana University-Purdue University at Indianapolis, United States*
[h] *Emory University School of Medicine, United States*

Received 23 February 2007; received in revised form 28 March 2007; accepted 30 March 2007

**Abstract**

*Objective:* To examine the nature and cause of patients' misunderstanding common dosage instructions on prescription drug container labels.
*Methods:* In-person cognitive interviews including a literacy assessment were conducted among 395 patients at one of three primary care clinics in Shreveport, Louisiana, Jackson, Michigan and Chicago, Illinois. Patients were asked to read and demonstrate understanding of dosage instructions for five common prescription medications. Correct understanding was determined by a panel of blinded physician raters reviewing patient verbatim responses. Qualitative methods were employed to code incorrect responses and generate themes regarding causes for misunderstanding.
*Results:* Rates of misunderstanding for the five dosage instructions ranged from 8 to 33%. Patients with low literacy had higher rates of misunderstanding compared to those with marginal or adequate literacy (63% versus 51% versus 38%, $p < 0.001$). The 374 (19%) incorrect responses were qualitatively reviewed. Six themes were derived to describe the common causes for misunderstanding: label language, complexity of instructions, implicit versus explicit dosage intervals, presence of distractors, label familiarity, and attentiveness to label instructions.
*Conclusion:* Misunderstanding dosage instructions on prescription drug labels is common. While limited literacy is associated with misunderstanding, the instructions themselves are awkwardly phrased, vague, and unnecessarily difficult.
*Practice implications:* Prescription drug labels should use explicit dosing intervals, clear and simple language, within a patient-friendly label format. Health literacy and cognitive factors research should be consulted.


*Keywords:* Prescription; Drug; Medication; Dosage; Instructions; Warnings; Misunderstanding; Health literacy

## 1. Introduction

According to the Institute of Medicine (IOM) 2006 report, *Preventing Medication Error*, more than one third of the 1.5 million adverse drug events that occur in the United States each year happen in outpatient settings [1]. Problems with prescription drug labeling were specifically cited as a leading root cause of a large proportion of outpatient medication errors and adverse events, as patients may unintentionally misuse a prescribed medicine due to improper understanding of instructions. The prescription container label, in particular, is often the sole, tangible source of specific dosage/usage instructions given to and repeatedly used by the patient. Despite their potential value, problems are clearly evident with container labels [2–5]. Dosage instructions on the label can vary, as they are dependent on what the prescribing physician writes, as well as how the pharmacist interprets them [6,7]. With little guidance available to providers, instructions

* Corresponding author at: Health Literacy and Learning Program, Institute for Healthcare Studies and Division of General Internal Medicine, Northwestern University, 676 N. St. Clair Street, Suite 200, Chicago, IL 60611, United States. Tel.: +1 312 695 0459; fax: +1 312 695 4307.
*E-mail address:* mswolf@northwestern.edu (M.S. Wolf).

0738-3991/$ – see front matter © 2007 Published by Elsevier Ireland Ltd.
doi:10.1016/j.pec.2007.03.024

commonly found on prescription drug labels may not always be clearly stated. In prior studies, half of adults in outpatient primary care settings misunderstood one or more primary and auxiliary prescription instructions and warnings they encountered [2–4]. Patients with limited literacy skills and those managing multiple medication regimens made more errors.

Improving prescription drug container label instructions is both a matter of health literacy and *patient safety* [1,8,9]. This is especially true since other sources of patient medication information are insufficient. Prior studies have found that physicians and pharmacists frequently miss opportunities to adequately counsel patients on newly prescribed medicines [10–12]. Other supplementary sources, such as consumer medication information sheets and FDA-approved medication guides that may be dispensed with a prescribed medicine are too complex and written at a reading grade level too high for the majority of patients to comprehend [13]. As a result, these materials are not read [13–15]. Patients' ability to decipher the brief text instructions on the container label itself takes on greater importance to ensure proper use.

### 1.1. Sources of comprehension failure: a conceptual model

The ability to read and understand prescription label instructions may appear to be a simple task, yet van den Broek & Kremer describe various sources of failure in comprehension that are particularly applicable for the abbreviated text on container labels [16–18]. These include readers' cognitive characteristics, constraints on the reading situation, and the nature of the presented health information. The influence of the latter set of factors is particularly applicable to the truncated text on container labels, and may include text complexity, formatting and organizational issues. Failure may also occur if instructions are not explicit, or if purpose is not evident, such as providing an indication for use on the bottle label itself (i.e. ''take for diabetes''), which is not part of routine practice for either physicians to add to the script or pharmacists to include on the dispensed container label. The presence of distracting information may limit comprehension of the pertinent dosage/usage instructions and auxiliary warnings that patients need to understand in order to safely use a medicine. This might include the more prominently displayed pharmacy logo, phone number, serial number and drug code, and other provider-directed content on the label.

### 1.2. Purpose of study

The purpose of this study was to investigate how patients approached and interpreted prescription drug label instructions, and to document the nature of misunderstanding that may contribute to the high prevalence of medication error. We took a health literacy perspective towards the problem of misunderstanding prescription medication instructions. From this view, it was hypothesized that misunderstanding would be the result of both patient literacy limitations and the ambiguity and inherent difficulty of label instructions themselves.

## 2. Methods

The methods and quantitative findings from this research study that detail the relationship between patient literacy and misunderstanding prescription label instructions have been reported upon previously [2].

### 2.1. Subjects

Subjects were adult patients who attended one of three outpatient primary care clinics serving low-income community populations in Shreveport, Louisiana, Jackson, Michigan and Chicago, Illinois. Recruitment took place over consecutive summers beginning July 2003. Patients were eligible if they were 18 or older, and ineligible if the clinic nurse or study research assistant identified a patient as having one or more of the following conditions: (1) blindness or severely impaired vision not correctable with eyeglasses; (2) deafness or hearing problems uncorrectable with a hearing aid; (3) too ill to participate; (4) non-English speaking. Institutional Review Boards at each location approved the study.

A total of 458 patients were approached in the order they arrived at the clinics and prior to the medical encounter. Twelve patients refused participation 26 were deemed ineligible, and 25 had incomplete information, leaving 395 patients participating in the study. A response rate was determined following American Association for Public Opinion Research (AAPOR) standards; 92% of approached eligible patients participated in the study [19].

### 2.2. Structured interview and literacy assessment

A structured, cognitive interview protocol was developed to assess understanding of different label dosage instructions placed on five common prescription medications. This process has been widely used by the research team, among others [2–4,20,21]. These included two antibiotics (amoxicillin (for pediatric use) and trimethoprim), an expectorant (guaifenesin), an anti-hypertensive, channel blocking agent (felodipine), and a diuretic (furosemide). A trained research assistant (RA) at each site administered the interview to consenting patients that included self-report of sociodemographic information (age, gender, race/ethnicity, education) source of payment for medications, and number of prescription medications currently taken daily. Actual prescription pill bottle containers with labels were then shown to patients, one at a time, for review. Once patients provided their interpretation on all of the labels, the RA administered a brief literacy assessment, ending the interview.

#### 2.2.1. Understanding of medication primary container label instructions

To assess patient understanding of prescription medication instructions included on the container primary labels, the RA asked ''how would you take this medicine?'' This question was often followed by one to two short probes (i.e. ''anything else?'', ''exactly how would you take the pills [medicine]?'') to

initiate more detailed description of administration. The RA documented the verbatim response on a separate form. Responses to the instructions for the five medications ($N = 1{,}975$) were then independently rated correct or incorrect by three general internal medicine attending physicians from three different academic medical centers. Each physician rater was blinded to all patient information and was trained to follow stringent coding guidelines agreed upon previously by the research team. Correct scores were to be given only if patient responses included all aspects of the label's instruction, including dosage, timing, and if applicable, duration.

Inter-rater reliability was high ($\kappa = 0.85$). The 147 responses (7.4%) that received discordant ratings between the three reviewers were sent to an expert panel that included three primary care physicians and two health literacy experts for further review. Each panel member, also blinded to patient information, independently reviewed and coded responses as correct or incorrect. For 76.2 % ($n = 112$) of the 147 responses, consensus was achieved among the five-member panel. A majority rule was imposed for the remaining responses ($n = 35$).

#### 2.2.2. Attendance to auxiliary (secondary) warning label instructions

Attentiveness to the auxiliary or ''secondary'' warning label on the pill bottles by patients was also investigated. These labels provide supplementary instructions supporting the safe administration of the medications, such as ''take with food'' or ''do not chew or crush, swallow whole.'' RAs were instructed during the interview to document (yes or no) whether patients either attempted to interpret the auxiliary label along with the primary label, or physically turned the bottle to inspect the color stickers on which these warning messages are placed.

#### 2.2.3. Reading versus demonstrating instructions

Patients were further tested on their functional understanding of the primary label instruction for guaifenesin (''take two tablets by mouth twice daily''). They were asked to demonstrate how many pills were to be taken on a daily basis. After patients answered the first question, ''how would you take this medicine?'' they were asked, ''show me how many pills you would take [of this medicine] in one day''. The container was filled with candy pills for patients to dispense and count out the correct amount. Responses were coded as correct if their answer was ''four'', and incorrect if any other response was provided.

#### 2.2.4. Literacy assessment

Patient literacy was assessed using the Rapid Estimate of Adult Literacy in Medicine (REALM), a reading recognition test comprised of 66 health-related words [22]. The REALM is the most commonly used test of patient literacy in medical settings [23]. In healthcare studies where patients need only be categorized as low (scores 0–44), marginal (scores 45–60) or adequate (scores 61–66) readers, the information provided by the REALM is generally sufficient. The REALM is highly correlated with standardized reading tests and the Test of Functional Health Literacy in Adults (TOFHLA) [23,24].

### 2.3. Analysis plan

Mixed methods were used. Chi-square tests were calculated to examine bivariate associations between health literacy (adequate, marginal, low), sociodemographic variables (age, gender, race, education, number of medications currently taken), and understanding (yes or no) primary label instructions and attendance (yes or no) to the auxiliary warning instructions. Quantitative analyses were conducted using Stata 9.0 (College Station, TX).

For qualitative analyses, a grounded theory approach was used to explore the basis for patients' misunderstanding of each of the five dosage instructions using their documented verbatim responses [25]. Grounded theory is a systematic method for generating theoretical statements from case studies. Based on our qualitative, cognitive interviews, grounded theory guides the inductive process of organizing content derived from patient responses. Patient misunderstandings were first reviewed by investigators (MSW, TCD, RMP) and classified using both selective and *in vivo* coding schemes [26]. Data were then reduced by one of the lead investigators (MSW) through detailed a priori coding to classify the reason for error in understanding (label language, complexity, explicitness of instruction, presence of distracters, and label familiarity). These predetermined codes were based on previous studies and the conceptual model of sources of comprehension failure [16]. The reduced data was confirmed based on the a priori coding scheme, and *in vivo* codes were allowed to develop based on emergent themes in responses. Agreement among investigators was sought prior to classifying patient responses with any new themes. Open coding techniques were used [27]. Qualitative analyses were supported by NVivo 7 software (QSR International; Doncaster, Australia).

## 3. Results

### 3.1. Description of study sample

Table 1 describes the study sample in detail, stratified by literacy. The mean age was 45 years (S.D. = 14; range 19–85 years). Fifty-seven percent of patients were recruited from Shreveport, Louisiana, 25% from Jackson, Michigan, and 18% from Chicago, Illinois. Two-thirds (68%) were female, approximately half of patients were African American (47%) and half white (48%), and 28% reported less than a high school level of education attainment. Patient literacy was limited; 19% were reading at or below a sixth grade level (low literacy) and 29% were reading at the seventh to eighth grade level (marginal literacy).

Patients were taking an average of three prescription medications, and 23% lacked insurance to cover these prescribed drugs. The physician was the most likely source of medication information for patients (71%). Low literacy was associated with older age ($p < 0.001$), African American race ($p < 0.001$), and less education ($p < 0.001$); differences were also noted by site ($p < 0.002$). No significant differences

Table 1
Sample characteristics stratified by literacy level

| Characteristic | Literacy level | | | *p*-Value |
|---|---|---|---|---|
| | Adequate ($n = 207$) | Marginal ($n = 113$) | Low ($n = 75$) | |
| Age, mean (S.D.) | 43 (14) | 45 (14) | 51 (13) | <0.001 |
| Female (%) | 60 | 68 | 71 | 0.25 |
| Race (%) | | | | <0.001 |
| African American | 29 | 64 | 73 | |
| White | 65 | 33 | 25 | |
| Other | 6 | 4 | 1 | |
| Education (%) | | | | <0.001 |
| Grades 1–8 | 2 | 3 | 15 | |
| Grades 9–11 | 12 | 35 | 41 | |
| Completed High School/GED | 43 | 45 | 40 | |
| >High School | 44 | 18 | 4 | |
| Payment source for medications (%) | | | | 0.43 |
| Private insurance | 19 | 14 | 12 | |
| Medicaid | 46 | 56 | 59 | |
| Out of pocket | 25 | 20 | 23 | |
| Other | 10 | 11 | 7 | |
| Source of support for understanding prescription medication instructions (%) | | | | |
| Physician | 71 | 72 | 68 | 0.81 |
| Nurse | 10 | 12 | 19 | 0.12 |
| Pharmacist | 45 | 53 | 57 | 0.35 |
| Family member | 22 | 9 | 4 | <0.001 |
| Number of medications taken daily, mean (S.D.) | 2 (1) | 2 (1) | 1 (1) | 0.37 |
| Misunderstanding 1 or more dosage instructions (%) | 38 | 51 | 63 | <0.001 |

were reported between literacy, gender, source of payment for medications, or number of prescription medications taken daily.

### 3.2. Prevalence and associations of misunderstanding dosage instructions

Overall, 46% of patients misunderstood one or more dosage instructions. The prevalence of misunderstanding among patients with adequate, marginal and low literacy was 38%, 51%, and 63%, respectively ($p < 0.001$). The rates of misunderstanding individual labels ranged from 8% for the instructions on the label for Felodipine (‘‘Take one tablet by mouth once each day’’) to 33% for the instructions for Trimethoprim (‘‘Take one tablet by mouth twice daily for 7 days’’; Table 2). Patients with low literacy were less able to understand instructions compared to those with adequate literacy.

### 3.3. Reading versus demonstrating dosage instructions

The ability to read dosage instructions did not always preclude the ability to demonstrate a functional understanding of prescription drug use (Fig. 1). When asked how pills were to be taken in a given day for the instruction, ‘‘Take two tablets by mouth twice daily’’, one third of patients were unable to correctly state ‘‘four pills’’. Rather, the most common incorrect answer was ‘‘two pills’’. Patients with low literacy were less able to state the correct number of pills taken daily compared to those with marginal and adequate literacy (35% versus 63% versus 80%, $p < 0.001$). No statistically significant associations were noted by number of medications or age.

### 3.4. Nature of patient misunderstanding label dosage instructions

The 374 (18.9%) total responses that were coded as incorrect were qualitatively reviewed and coded using the pre-selected

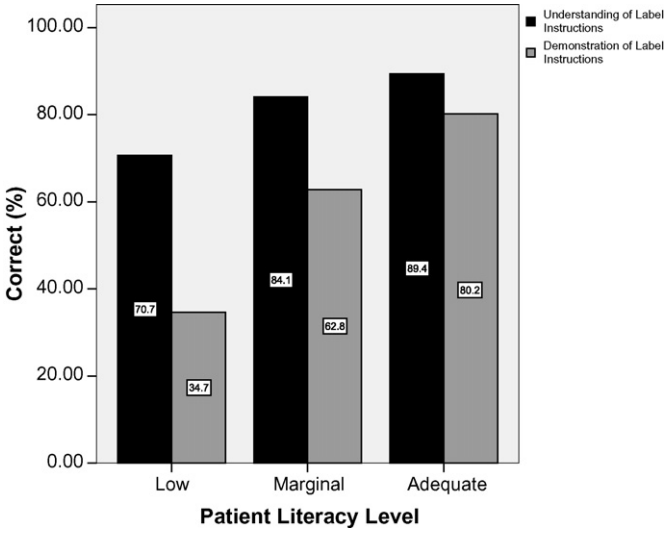


Fig. 1. Rates of correct understanding vs. Demonstration for the primary label instruction, ‘‘Take two tablets by mouth twice daily’’.

Table 2
Rates of understanding primary label instructions and attendance to auxiliary warnings, stratified by literacy level

| Generic drug name (dose) | Primary instructions and auxiliary warnings[a] | Literacy level | | | *p*-Value |
|---|---|---|---|---|---|
| | | Adequate ($n = 207$) | Marginal ($n = 113$) | Low ($n = 75$) | |
| Amoxicillin | | | | | |
| Correctly interpreted primary label | Take one teaspoonful by mouth three times daily | 86 | 66 | 59 | <0.001 |
| Attended to auxiliary label(s) | Refrigerate, shake well, discard after [date] | 5 | 4 | 0 | 0.13 |
| Trimethoprim | | | | | |
| Correctly interpreted primary label | Take one tablet by mouth twice daily for 7 days | 73 | 66 | 52 | <0.001 |
| Attended to auxiliary label(s) | You should avoid prolonged or excessive exposure to direct and/or artificial sunlight while taking this medication | 8 | 7 | 1 | 0.14 |
| Guaifenesin | | | | | |
| Correctly interpreted primary label | Take two tablets by mouth twice daily | 89 | 84 | 70 | <0.001 |
| Demonstrated understanding | | 80 | 63 | 35 | <0.001 |
| Attended to auxiliary label(s) | Medication should be taken with plenty of water | 14 | 7 | 0 | <0.001 |
| Felodipine | | | | | |
| Correctly interpreted primary label | Take one tablet by mouth once each day | 95 | 88 | 87 | 0.03 |
| Attended to auxiliary label(s) | Do not chew or crush, swallow whole | 13 | 11 | 4 | 0.11 |
| Furosemide | | | | | |
| Correctly interpreted primary label | Take one tablet in the morning and one at 5 p.m. | 91 | 91 | 83 | 0.09 |
| Attended to auxiliary label(s) | Do not take dairy products, antacids, or iron preparations within 1 h of this medication | 15 | 9 | 3 | 0.01 |

[a] Included behavioral demonstration for Guaifenesin only.

coding scheme of likely causes for error in interpretation (Table 3). One emergent cause, referred to as attentiveness to label instructions, was included in addition to the predetermined causes of label language, complexity of instructions, implicit versus explicit dosage, presence of distracters, and label familiarity.

### 3.4.1. Label language

Certain common phrases used on medicine labels seemed confusing and unfamiliar to patients within the context of the instruction itself. Errors that appeared to be the result of label language were most prevalent on the instruction, ''Take two tablets by mouth twice daily''. The repetitiveness between dosage (''two'') and frequency (''twice'') often led to the common interpretation ''Take a pill twice a day'', whereas dosage would go ignored. This was confirmed in the follow-up demonstration task, ''How many pills would you take in one day'' with the common incorrect response of ''two'' (72% of incorrect responses).

Many terms commonly used on prescription labels had exceptionally poor recognition rates by patients. Specifically, among patients reading at the 6th grade level and below ($n = 75$), 79% of these patients could not recognize and pronounce ''antibiotic'', 73% ''orally'', 70% ''teaspoonful'', 48% ''medication'', 45% ''prescription'', and 35% the word ''dose''. Poor word recognition may have contributed to patients misreading words on labels, such as ''tablespoon'' instead of ''teaspoon''. This accounted for 9% of errors ($n = 34$).

Interestingly, feedback documented by RAs from patient interviews recommended the use of numeric symbols within the instruction rather than the written word equivalent (i.e. ''2'' versus ''two'') for further reading ease.

### 3.4.2. Complexity of instructions

Instructions ranged in complexity, both with regards to the calculation of the number of pills and times to be taken daily (i.e. ''Take one pill by mouth once each day'' versus, ''Take two tablets by mouth twice daily'') and in the amount of content to be retained (dosage, frequency, and/or duration, as in ''Take one tablet by mouth twice daily for seven days''). Patients found simpler dosing regimens to be easier to understand, while more complex regimens had more errors in their interpretation (Table 2). Eleven percent ($n = 41$) of incorrect responses

Table 3
Examples of the most common misunderstandings, by dosage instruction

| Dosage instruction | Misunderstanding |
|---|---|
| Take one teaspoonful by mouth three times daily | Take three teaspoons daily; take three tablespoons every day; you should drink it three times a day |
| Take one tablet by mouth twice daily for 7 days | Take two pills a day; take it for 7 days; take one every day for a week; I'd take a pill every day for 7 days |
| Take two tablets by mouth twice daily | Take it every 8 h; take it every day; take one every 12 h |
| Take one tablet by mouth once each day | Take it as directed |
| Take one tablet in the morning and one at 5 p.m. | I would take it every day at 5 o'clock; take it at 5 p.m. |

omitted duration of use from the specified instruction. The inclusion of duration on the label instruction also led to a loss of other aspects of the instruction. For the label, ''Take one tablet by mouth twice daily for seven days'', the second most common error made was an incorrect interpretation of dosing frequency ($n = 34$; i.e. ''I'd take a pill every day for seven days'').

#### 3.4.3. Implicit versus explicit dosage intervals

Patients were better able to interpret more explicit dose frequencies as in ''Take one tablet in the morning and one at 5 p.m.'' (90%), compared with the more vague ''Take two tablets by mouth twice daily'' (83%), and ''Take one teaspoonful by mouth three times daily'' (73%). For the latter two instructions, patients varied in their interpretation of ''twice daily'' and ''three times daily''. For example, patients interpreted ''twice daily'' as both ''every 8 h'' and ''every 12 h'', and ''three times daily'' ranged from ''every 4 h'' to ''every 8 h''.

#### 3.4.4. Presence of distracters

In 6% ($n = 21$) of the incorrect responses, patients had difficulty navigating the label content itself and identifying the instructional content. Rather than describing the dosage of the medicine, responses detailed provider-directed content that surrounded and may have obscured the dosage instructions (i.e. stated combinations for the name of the drug, physician's name, refill and date). Patients turned the bottle to acknowledge auxiliary warnings, as they were also recited along with the provider-directed content instead of the dose and frequency for use (i.e. ''Take it with Food''; ''I would take them every day but not with dairy products, antacids, or iron preparations''; ''I would stay out of the heat'').

#### 3.4.5. Label familiarity

Auxiliary instructions are often placed as stickers surrounding or in back of the primary label. Very few patients were familiar with these instructions. Less than 10% of patients physically turned any of the bottles to examine these stickers (Table 2). Sixteen percent of patients attended to at least one auxiliary instruction, and 2% made the action part of the routine inspection of the prescription bottle for all five medicines.

#### 3.4.6. Attentiveness to label instructions

Several patients provided detailed responses that verbally 'implemented' the regimen (''It's an antibiotic, and I would take one pill in the morning when I wake, and another pill after dinner—I would do that for a week''). Even though tasks were not timed, many patients appeared to have responded quickly, and by doing so made simple mistakes. When answers were provided in haste, patients often skipped or omitted dosage information (''Take two a day''; ''I'd take three pills daily'').

Patients with adequate literacy were more likely than patients with low literacy to omit the duration of use for the instruction, ''Take one tablet by mouth twice daily for seven days'' ($n = 41$; 44% versus 18%, $p < 0.001$). They were equally likely to make errors wherein dose and interval were inverted for the same instruction and for ''Take one teaspoonful by mouth three times daily'' ($n = 60$; 39% versus 43%, $p = 0.65$). Mistaking ''teaspoon'' for ''tablespoon'' was more common among patients with limited literacy, but one third of these errors were made by patients with adequate literacy ($n = 12$).

## 4. Discussion and conclusion

### 4.1. Discussion

Although there may be a finite number of ways a physician can prescribe a medicine, the same dose and frequency schedule may be written in several different ways (i.e. every 12 h, twice daily, in the morning and evening, 8 a.m. and 5 p.m., etc.). This becomes especially problematic as many patients may have more than one healthcare provider prescribing medicine [28]. The ability to follow instructions is crucial in ambulatory care, since the patient assumes the bulk of responsibility for medication safety. Our present research offers timely evidence classifying the nature and causes of patient misunderstanding of commonly-written dosage instructions that could potentially lead to errors and adverse events [1].

Our prior studies have repeatedly shown that limited literacy significantly impairs one's ability to read and demonstrate an understanding of instructions and warnings found on commonly prescribed medicines [2–5]. While individual differences in reading ability may be related to a greater risk for misunderstanding, problems are clearly evident with the label itself, and the implicit nature and syntax of instructions. Improving the reading ease of dosage instructions is therefore warranted.

Many patients might presume the task of reviewing prescription drug labels to be overly simple. As a result, they may not allot adequate time to process and understand the information. This could explain why a majority of patients were able to read back the instruction, while far fewer could demonstrate a proper understanding when probed further. An earlier study by Morrell and colleagues found that older adults, who on average manage more medications than younger patients, spent less time processing dosage instructions and consequently made more errors in interpretation [29]. These mistakes could lead to compromised health outcomes, such as under-treatment (i.e. taking two rather than four pills a day) or possible harm (i.e. taking too much of a medicine or not attending to warnings).

The manner in which physicians write dosage instructions requires patients to make inferences as to when to specifically implement the prescribed regimen (i.e. Take two tablets by mouth twice daily; Take one teaspoon by mouth three times daily). Our findings suggest that patients' interpretations may widely vary when dosing intervals are presented in vague terms as ''twice daily'' or ''three times daily'', which may stray from the original intent of the prescribing physician. Park and colleagues suggest that making inferences is a complex cognitive process, and the elderly may have greater difficulty when faced with these types of tasks [30].

Some misunderstandings appeared to be the result of container label organization. The prescription labels were

typical of the order in which most pharmacies present drug information, often emphasizing (by yellow highlight, large font, bold text) content that is irrelevant to the patient. The inclusion of such distracting information may be particularly problematic for individuals with limited literacy, who face greater reading difficulty in less familiar and technical contexts [31].

### 4.2. Limitations

We investigated patient understanding of prescription drug label instructions, not whether a medication error occurred. Patients' actual prescription drug-taking behaviors were not examined. Patients' motivation, concentration and comprehension might have been greater if they reported on their own medicine. Similarly, we interviewed patients before their medical encounter. It is also possible that the reason for the medical visit altered patients' concentration, although patients were offered the opportunity to refuse and anyone too acutely ill was not interviewed. We also did not conduct a chart review, and thereby could not identify if patients had actual experience with any of the study medications. Only patients who were proficient in the English language were also included. This was due in part to criteria for using the Rapid Estimate of Adult Literacy in Medicine (REALM) as our literacy assessment. Further research should investigate the effect of cultural differences and language barriers on misunderstanding prescription drug label instructions.

### 4.3. Conclusion

Prescription drug labels often are the only print source of dosage instructions received by patients. Given the tangible nature of the prescription bottle, these label instructions may be the 'last line' of informational support detailing how and when a patient should administer a prescribed medicine. Yet many of the common phrases used to describe dosage instructions are inadequately written and contribute to misunderstanding. Patients with limited literacy may face greater difficulty when attempting to infer and interpret instructions. Research is needed to evaluate the use of enhanced strategies of communicating dosage information and warnings for improving comprehension among patients across all literacy levels. In the end, all patients would benefit from more clearly presented prescription drug information.

### 4.4. Practice implications

Unfortunately, there are only minimal standards and regulations set by state boards of pharmacy that dictate any recommendations for content and organization of prescription drug labels [32]. As such, rules vary by state. Our research study provides initial guidance for improving the dosage instructions on prescription bottles, and 'best practices' can be derived from our study. These are supported by health literacy principles and cognitive/human factors research [31–33].

#### 4.4.1. Use explicit language when describing dose intervals.

Three previous studies also found more explicit instruction improved comprehension [34–36]. This might help pace patients and allow them to direct necessary attention for processing each component of dosage. For instance, the actual dose (number of pills to be taken at a time) could be separated from the interval (times per day), as in the example "Take 2 tablets in the morning, and take 2 tablets in the evening."

#### 4.4.2. Organize label in a way to minimize distracters

The label should be re-organized, separating distracting elements that often comprise provider-directed content (pharmacy logo, drug serial number, pharmacy address and phone number) away from dosage instructions. Auxiliary instructions might also be placed in a set location (i.e. backside of label), instead of being stuck on in various locations, so patients can have routine expectations of their location.

#### 4.4.3. Simplify language

Doak, Doak, and Root (1993) offer guidance as to how to make health information more suitable for patients with limited literacy, such as dosage instructions and warning messages on auxiliary labels. The use of numbers rather than the text equivalent should be promoted for reading ease, and unclarified medical jargon (i.e. antibiotic) or awkward terms (i.e. twice) avoided.

## Acknowledgements

We would like to thank Mary Bocchini, Katherine Davis, and Silvia Skripkauskas for their assistance in implementing this study.

Funding: Dr. Wolf is supported by a career development award through the Centers for Disease Control and Prevention (1 K01 EH000067-01).

## References

[1] Institute of Medicine. In: Aspden P, Wolcott J, Bootman L, Cronenwett LR, editors. Preventing medication errors. Washington, DC: National Academy Press; 2006.
[2] Davis TC, Wolf MS, Bass PF, Tilson H, Neuberger M, Parker RM. Literacy and misunderstanding of prescription drug labels. Ann Intern Med 2006;145:887–94.
[3] Davis TC, Wolf MS, Bass PF, Middlebrooks M, Kennan E, Baker DW, Bennett CL, Durazo-Arvizu R, Savory S, Parker RM. Low literacy impairs comprehension of prescription drug warning labels. J Gen Intern Med 2006;21:847–51.
[4] Wolf MS, Davis TC, Bass PF, Tilson H, Parker RM. Misunderstanding prescription drug warning labels among patients with low literacy. Am J Health System Pharm 2006;63:1048–55.
[5] Shrank W, Avorn J, Rolon C, Shekelle P. Effect of content and format of prescription drug labels on readability, understanding, and medication use: a systematic review. Ann Pharmacother 2007;41:783–801.
[6] Dunn EB, Wolfe JJ. Let go of Latin! Vet Hum Toxicol 2001;43:235–6.
[7] Gupta AK, Cooper EA, Feldman SR, Fleischer Jr AB, Balkrishnan R. Analysis of factors associated with increased prescription illegibility: results from the National Ambulatory Medical Care Survey. Am J Manag Care 2003;9:548–52.

[8] Institute of Medicine. In: Nielsen-Bohlman L, Panzer A, Kindig DA, editors. Health literacy: a prescription to end confusion. Washington, DC: National Academy Press; 2004.
[9] Institute of Medicine. In: Kohn L, Corrigan J, Donaldson M, editors. To err is human: building a safer health system. Washington, DC: National Academy Press; 2000.
[10] Tarn DM, Heritage J, Paterniti DA, Hays RD, Kravitz RL, Wenger NS. Physician communication when prescribing new medications. Arch Intern Med 2006;166:1855–62.
[11] Morris LA, Tabak ER, Gondel K. Counseling patients about prescribed medications: 12-year trend. Med Care 1997;35:996–1007.
[12] Metlay JP, Cohen A, Polsky D, Kimmel SE, Koppel R, Hennessy S. Medication safety in older adults: home-based practice patterns. J Am Geriatr Soc 2005;53:976–82.
[13] Wolf MS, Davis TC, Shrank W, Neuberger M, Parker RM. A critical review of FDA-approved medication guides. Pat Educ Counsel 2006;62:316–22.
[14] Krass I, Svarstad BL, Bultman D. Using alternative methodologies for evaluating patient medication leaflets. Pat Educ Counsel 2002;47:29–35.
[15] Gustafsson J, Kalvemark S, Nilsson G, Nilsson JL. Patient information leaflets: patients' comprehension of information about interactions and contraindications. Pharm World Sci 2005;27:35–40.
[16] van den Broek P, Kremer K. The mind in action: what it means to comprehend. In: Taylor B, van den Broek P, Graves M, editors. Reading for meaning. New York: Teacher's College Press; 2000.
[17] Rapp DN, van den Broek P. Dynamic text comprehension: an integrative view of reading. Cur Direct Psychol Sci 2005;14:276–9.
[18] Rapp DN, Samuel A. A reason for rhyme: phonological and semantic influences on lexical access. J Exp Psychol Learn 2002;28:564–71.
[19] American Association for Public Opinion Research. Standard definitions: final dispositions of case codes and outcome rates for surveys, 3rd ed., Lenexa, Kansas: AAPOR; 2004.
[20] Willis SL, Jay GM, Diehl M, Marsiske M. Longitudinal change and prediction of everyday task competence in the elderly. Res Aging 1992;14:68–91.
[21] Willis SL, Dolan MM, Bertrand RM. Problem solving on health-related tasks of daily living. In: Park DC, Morrell RW, Shiffren D, editors. Processing of medical information in aging patients. Mahwah, NJ: Lawrence Ehrlbaum Associates; 1999. p. 199–222.
[22] Davis TC, Michielutte R, Askov EN, Williams MV, Weiss BD. Practical assessment of adult literacy in healthcare. Health Ed Beh 1998;25:613–24.
[23] Davis TC, Kennen EM, Gazmararian JA, Williams MV. Literacy testing in health care research. In: Schwartzberg JG, VanGeest JB, Wang CC, editors. Understanding health literacy: implications for medicine and public health. Chicago, IL: AMA Press; 2004.
[24] Parker RM, Baker DW, Williams MV, Nurss JR. The test of functional health literacy in adults: a new instrument for measuring patients' literacy skills. J Gen Intern Med 1995;10:537–41.
[25] Strauss A, Corbin J. Basics of qualitative research: grounded theory procedures and techniques. Newbury Park, CA: Sage Publications; 1990
[26] Miles MB, Huberman AM. Qualitative data analysis: an expanded sourcebook, 2nd ed., Thousand Oaks, CA: Sage Publications; 1994.
[27] Emerson RM, Fretz RI, Shaw LL. Writing ethnographic fieldnotes. Chicago: University of Chicago Press; 1995.
[28] Medical Expenditure Panel Survey [on-line]. Available at http://www.meps.ahrq.gov. Accessed January 3, 2006.
[29] Morrell RW, Park DC, Poon LW. Quality of instructions on prescription drug labels: effects on memory and comprehension in young and old adults. Gerontologist 1989;29:345–54.
[30] Park DC, Morrell RW, Frieske D, Blackburn AB, Birchmore D. Cognitive factors and the use of over-the-counter medication organizers by arthritis patients. Hum Factors 1991;33:57–67.
[31] Doak CC, Doak LG, Root JH. Teaching patients with low-literacy skills, 2nd ed., Philadelphia, PA: JB Lippincott; 1996.
[32] Root J, Stableford S. Write it easy-to-read: a guide to creating plan English materials (especially for the Medicaid market). Biddeford, Maine: Health Literacy Center, University of New England; 1998.
[33] Park DC, Morrell RW, Shifren K, editors. Processing of medical information in aging patients: cognitive and human factors perspectives. Mahwah, NJ: Lawrence Erlbaum Associates; 1999.
[34] Bull SA, Hu XH, Hunkeler EM, Lee JY, Ming EE, Markson LE, Fireman B. Discontinuation of use and switching of antidepressants: influence of patient–physician communication. JAMA 2002;288:1403–9.
[35] Swanson JM, Forrest K, Ledbetter C, Hall S, Holstine EJ, Shafer MR. Readability of commercial and generic contraceptive instructions. Image J Nurs Sch 1990;22:96–100.
[36] Ngoh LN, Shepherd MD. Design, development, and evaluation of visual aids for communicating prescription drug instructions to nonliterate patients in rural Cameroon. Pat Educ Counsel 1997;30(3):257–70.