Poor Adherence to Medications May Be Associated with Falls

Sarah D. Berry,1,2 Lien Quach,1 Elizabeth Procter-Gray,3 Douglas P. Kiel,1,2 Wenjun Li,3 Elizabeth J. Samelson,1,2 Lewis A. Lipsitz,1,2 and Jennifer L. Kelsey3

1Institute for Aging Research, Hebrew SeniorLife, Boston, Massachusetts.  
2Department of Medicine, Division of Gerontology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts.  
3Division of Preventive and Behavior Medicine, University of Massachusetts Medical School, Worcester.

Address correspondence to Sarah D. Berry, MD MPH, Institute for Aging Research, Hebrew SeniorLife, 1200 Centre Street, Boston, MA 02131. Email: sarahberry@hrca.harvard.edu

Background. Poor medication adherence is associated with negative health outcomes. We investigated whether poor medication adherence increases the rate of falls as part of Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston (MOBILIZE Boston), a prospective, community-based cohort recruited for the purpose of studying novel risk factors for falls.

Methods. A total of 246 men and 408 women (mean age, 78 years) were followed for the occurrence of falls (median follow-up, 1.8 years). Adherence was assessed by the Morisky scale based on the following four questions: whether an individual ever forgets, is careless at times, stops taking medications when feels better, or stops taking medications when feels worse. Low adherence was defined as a “yes” answer to one or more questions. High adherence was defined as a “no” answer to every question.

Results. Forty-eight percent of subjects were classified as having low medication adherence. The rate of falls in the low adherence group was 1.1 falls/person-year (95% confidence interval [CI]: 1.0–1.3) compared with 0.7 falls/person-year (95% CI: 0.6–0.8) in the high adherence group. After adjusting for age, sex, race/ethnicity, education, alcohol use, cognitive measures, functional status, depression, and number of medications, low medication adherence was associated with a 50% increased rate of falls compared with high medication adherence (rate ratio = 1.5, 95% CI: 1.2–1.9; p < .001).

Conclusions. Low medication adherence may be associated with an increased rate of falls among older adults. Future studies should confirm this association and explore whether interventions to improve medication adherence might decrease the frequency of falls and other serious health-related outcomes.

Key Words: Falls—Community—Medication adherence.

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METHODS

Study Participants
Subjects included participants of MOBILIZE Boston, a prospective cohort study comprised of a sample of community-dwelling elders in the greater Boston area (17,18). Eligibility criteria included: (a) age 70 years and above, (b) residence within 5-mile radius of Hebrew Rehabilitation Center, (c) ability to hear and speak English language, (d) lack of significant cognitive impairment (Mini-Mental Status Examination [MMSE] ≥ 18), and (e) ability to ambulate 20 feet without the assistance of another person.

A total of 4,303 individuals were identified from town lists as being 70 years and older. Using doorstep recruitment, 6% (n = 280) refused to participate, 5% (n = 171) were unable to be contacted, and one third were ineligible (n = 1,440). In a second stage of telephone screens, 57% (n = 1,360) refused to participate, 3% (n = 72) were unable to be contacted, and 6% (n = 133) were ineligible. After a final home interview stage, 5% (n = 44) refused to participate and 1% (n = 8) were ineligible. An additional 16 persons aged 64–69 years, who were spouses or living with participants, were added to the cohort, for a total of 765 study participants.

Information on participants was collected during a baseline home visit and clinical assessment conducted at Hebrew Rehabilitation Center (2005–2007). Individuals who were not taking medications (n = 25) or had incomplete information on medication adherence (n = 86) were excluded from these analyses. This study was approved by the Institutional Review Board of Hebrew SeniorLife.

Falls
Falls, defined as unintentionally coming to rest on the floor or lower surface, were ascertained by self-report using falls calendar postcards (19) and telephone interviews. Falls calendars were provided to participants at the baseline visit and returned by mail monthly (October 2005 to October 2008). Any subject reporting a fall was asked to complete a telephone questionnaire to provide details regarding the circumstances of the fall. Syncopal falls were excluded. Individuals who failed to complete a fall calendar (<20% each month) were contacted by telephone to ascertain falls. Less than 2% of subjects were missing falls information after telephone interviews.

Medication Use
At the baseline home visit, participants were asked to provide interviewers all over-the-counter and prescription medications taken in the past 2 weeks. The Iowa Drug Information Service was used to categorize medications by pharmacological therapeutic class (20).

The total number of medications was ascertained from a count of all over-the-counter and prescription medications. We excluded topicals, herbals, vitamins, and minerals. We retained all other classes provided that participants used these medications during the 2 weeks before the baseline visit. Psychotropic medications were defined as use of any antidepressant, benzodiazepine, or antipsychotic.

Medication Adherence
Medication adherence was ascertained using the 4-item Morisky scale (Table 3; 21). Low adherence was defined as a “yes” answer to at least one of the four questions. High adherence was defined as a “no” answer to every question. In secondary analyses, we considered low medication adherence as a “yes” answer to each of the four items separately.

Other Characteristics of Interest
We considered the following characteristics at the baseline visit that have been associated with an increased risk of falls in at least one study (6–8,10,22,23) and may influence medication adherence: older age, female sex, white race, higher education, alcohol use, low functional status, decreased physical activity, cognitive impairment, poor executive function, poor visual acuity, depression, increased number of comorbidities, urinary incontinence, polypharmacy, and use of psychotropic medications.

Race/ethnicity, education level, and alcohol use were determined by self-report. Functional status was determined by the modified Katz Activities of Daily Living (ADL) scale (24). We classified subjects into two categories: (a) no difficulty in performing any of the five ADLs, and (b) difficulty or inability to perform one or more ADL independently.

Physical activity was measured by the Physical Activity Scale for the Elderly (PASE), a self-reported weighted score of 10 commonly performed activities, with higher numbers indicating greater physical activity (25).

Cognition was measured using the MMSE, with cognitive impairment defined as an MMSE score of less than 24 (26). Executive function was measured by time to complete Trails B test (seconds) (27). Visual acuity was measured in both eyes with corrective lenses using the Snellen eye chart, with poor acuity defined as best-corrected vision less than 40/100. Depression was ascertained using the Revised Center for Epidemiologic Studies Depression (CESD-R) instrument with severe depression defined as a CESD-R score greater than 60 (28). We assessed burden of comorbidities using the modified Self-Administered Co-morbidity questionnaire (29), which determines the presence or absence of 12 major medical conditions by self-report (score 0–12).

Statistical Analysis
We compared differences in baseline characteristics between subjects with high and low adherence to medication using a Wilcoxon rank sum test for quantitative variables and a chi-square test for categorical variables. The annualized rate of falls was calculated as the total number of falls per person-year of follow-up. We used negative binomial regression
models to estimate the association of medication adherence (low vs high) with the rate of falls because subjects had unequal follow-up time and number of falls was unequally distributed in the cohort (i.e., most people had no or a small number of falls, whereas a few people had a large number of falls). We expressed the association of low medication adherence and the rate of falls as rate ratios (RR) with 95% confidence intervals (CI) (30).

In multivariable analyses, we decided a priori to adjust for age, sex, number of medications, and executive function. Other characteristics associated with the RR of falls at \( p \leq .1 \) in the bivariate analyses were considered for inclusion in the multivariable analysis. We then performed a backwards stepwise regression by sequentially removing characteristics that were the least significant as independent risk factors for falls in the multivariable model. Interactions between medication adherence and number of medications and medication adherence and alcohol use were considered because we hypothesized that medication adherence might impact the risk of falls differently in these groups. Interaction terms were not significant, and thus, they were not considered further. The adequacy of the multivariate model presented here was assessed using a goodness-of-fit test (\( p = .23 \)).

### Results

Subjects included 654 community-dwelling elders (246 men and 408 women). Mean age of participants was 78 years. During a median follow-up of 1.8 years (range, 0.6 months to 3.2 years), 376 subjects (141 men and 235 women) experienced a total of 1,052 falls.

Forty-one percent of subjects reported ever forgetting to take medications, and 6–13% reported sometimes being careless or not taking their medications when either feeling better or when they believed their medications made them feel worse. Overall, 48% of subjects were classified as having low medication adherence.

Subjects characterized as having low medication adherence were more likely to be non-white, have less than a high school education, report severe depression, urinary incontinence, more comorbidities, and to take more medications compared with subjects classified as having high adherence (Table 1). Although not statistically significant, subjects classified as having low medication adherence tended to have worse functional status, cognitive impairment, executive function, and visual acuity, whereas subjects classified as having high medication adherence were more likely to consume more than three to four alcoholic drinks/week.

<table>
<thead>
<tr>
<th>Characteristic, ( n (%) ) unless otherwise specified</th>
<th>Low adherence, ( (N = 314) )</th>
<th>High adherence, ( (N = 340) )</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(^a)</td>
<td>78 ± 5.3</td>
<td>79 ± 5.4</td>
<td>.02</td>
</tr>
<tr>
<td>Male</td>
<td>116 (37)</td>
<td>130 (38)</td>
<td>.73</td>
</tr>
<tr>
<td>Race (white)</td>
<td>231 (74)</td>
<td>278 (82)</td>
<td>.01</td>
</tr>
<tr>
<td>Consumes alcohol 3–4 days/week</td>
<td>70 (22)</td>
<td>93 (27)</td>
<td>.14</td>
</tr>
<tr>
<td>Greater than high school education</td>
<td>1188 (61)</td>
<td>234 (69)</td>
<td>.02</td>
</tr>
<tr>
<td>Functional status</td>
<td></td>
<td></td>
<td>.09</td>
</tr>
<tr>
<td>No difficulty with any of the five ADLs</td>
<td>230 (73)</td>
<td>268 (79)</td>
<td></td>
</tr>
<tr>
<td>Difficulty or inability to perform one or more ADL</td>
<td>84 (27)</td>
<td>72 (21)</td>
<td></td>
</tr>
<tr>
<td>Physical activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASE score(^b)</td>
<td>100.0 (53–138)</td>
<td>95.7 (56–145)</td>
<td>.27</td>
</tr>
<tr>
<td>Cognitive impairment(^c)</td>
<td>64 (20)</td>
<td>58 (17)</td>
<td>.28</td>
</tr>
<tr>
<td>Executive function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trails B time (s)(^d)</td>
<td>120 (85–193)</td>
<td>118 (81–185)</td>
<td>.20</td>
</tr>
<tr>
<td>Poor visual acuity(^e)</td>
<td>30 (10)</td>
<td>19 (6)</td>
<td>.06</td>
</tr>
<tr>
<td>Severe depression(^f)</td>
<td>73 (23)</td>
<td>51 (15)</td>
<td>.01</td>
</tr>
<tr>
<td>Co-morbidity index(^g)</td>
<td>3.3 ± 1.7</td>
<td>3.0 ± 1.5</td>
<td>.02</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>142 (45)</td>
<td>122 (36)</td>
<td>.01</td>
</tr>
<tr>
<td>Total number of medications</td>
<td></td>
<td></td>
<td>.02</td>
</tr>
<tr>
<td>1–4 medications</td>
<td>96 (31)</td>
<td>96 (28)</td>
<td></td>
</tr>
<tr>
<td>5–7 medications</td>
<td>107 (34)</td>
<td>150 (44)</td>
<td></td>
</tr>
<tr>
<td>&gt;7 medications</td>
<td>111 (35)</td>
<td>94 (28)</td>
<td></td>
</tr>
<tr>
<td>Psychotropic medication use</td>
<td>73 (23)</td>
<td>70 (21)</td>
<td>.41</td>
</tr>
<tr>
<td>Total number of falls</td>
<td>627</td>
<td>425</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Person-years of follow-up</td>
<td>585</td>
<td>614</td>
<td>.46</td>
</tr>
<tr>
<td>Number of falls per subject</td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>0</td>
<td>113 (36)</td>
<td>165 (49)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>62 (20)</td>
<td>79 (23)</td>
<td></td>
</tr>
<tr>
<td>≥2</td>
<td>139 (44)</td>
<td>96 (28)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: ADL = Activities of daily living; PASE = Physical Activity Scale for the Elderly.

\(^a\) Mean ± standard deviation.

\(^b\) Median (IQ range).

\(^c\) Mini-Mental Status Examination score <24.

\(^d\) Defined as <40/100.

\(^e\) Revised Center for Epidemiologic Studies Depression score <60.
Subjects characterized as having low medication adherence were more likely to experience two or more falls compared with subjects characterized as having high adherence (44% vs 28%; Table 1). The maximum number of falls experienced by a subject characterized as having high medication adherence was 18 compared with 12 in the low adherence group. The annualized fall rates in the low and high adherence groups were 1.1 (95% CI: 1.0–1.3) and 0.7 (95% CI: 0.6–0.8) falls/person-year, respectively.

The unadjusted RR for falls in the group with low medication adherence compared with the group with high medication adherence was 1.6 (95% CI: 1.3–1.9; p < .001; Table 2). In the adjusted model, the RR between the two groups changed little (RR = 1.5; 95% CI: 1.2–1.8; p < .001). We repeated the analysis excluding frequent fallers (defined as a fall rate that exceeded the 90th percentile for all subjects), and the results were similar. We additionally considered whether social support, as defined by the number of living children, affected the association, and the results were unchanged (results not shown).

When we considered low medication adherence as a “yes” response to each of the four separate items from the Morisky scale (Table 3), we found that low medication adherence was associated with an increased rate of falls for only the first of the four items, “Do you ever forget to take your medications?”

**Discussion**

We found that poor medication adherence was associated with an increased rate of falls among community-dwelling elders. This association persisted after adjusting for other variables, including age, sex, cognitive function, and total number of medications.

There are several plausible explanations for our findings. First, subjects with low medication adherence may be more frail, and thus, more susceptible to falls. However, controlling for number of medications and comorbidities did not change our findings. Nonetheless, we recognize that there may be unmeasured or inadequately measured confounders, such as access to medical care, which could in part explain our findings.

Second, subjects with low adherence to medications may be less cautious and less likely to avoid situations associated with a high fall risk. We did not collect information on risk-taking behaviors, and thus, we are unable to test this hypothesis.

Finally, subjects with low adherence to medications may be at an increased risk of falls because they have limited physiological reserve as a result of their poor adherence. For example, failure to consistently take antihypertensive mediations may cause marked fluctuations in blood pressure, which could result in a transient lowered reserve for falls. On the other hand, failure to adhere with other classes of medications, such as sedatives, may actually decrease the risk of falls. We did not have information on adherence within specific drug classes, and thus we are unable to directly test this hypothesis. Nonetheless, when we repeated our analysis among psychotropic medication users, the results were unchanged.

To our knowledge, no previous studies have examined the effect of poor medication adherence on the risk of falls. A Canadian study of 319 community dwellers found a non-statistically significant increased risk of death, hospitalization, and emergency room visits among elders who were poorly adherent with prescription medications after controlling for age, functional status, cognitive status, comorbidities, and medication use (pooled Hazard Ratio = 1.24, 95% CI: 0.93–1.65) (31). No information was provided on the reason for medical service utilization in this study, and thus it is unknown whether falls contributed to the observed increase in adverse health outcomes.

Poor medication adherence may occur in as many as 40%–50% of community-dwelling elders (31,32). Previous
expected. This may be explained because our cohort was high
ated with an increased rate of falls as we might have ex-
medications and poor executive function, were not associ-
dwelling elders. Certain characteristics, such as number of
als (11%) were missing complete information on medication
als at greatest risk of falls. among participants, 86 individu-
order that our results be applicable to very elderly individu-
tively high-functioning English-speaking community-
clusion did not differ from study participants with respect to
characteristics including age and number of medications.
However, we performed a secondary analysis using im-
putation for subjects with incomplete information on med-
ication adherence and exclusion from our study. Individuals ex-
cluded did not differ from study participants with respect to
characteristics including age and number of medications.
Finally, this study was conducted among a cohort of rela-
tively high-functioning English-speaking community-
dwelling elders. Certain characteristics, such as number of
medications and poor executive function, were not associ-
ated with an increased rate of falls as we might have ex-
This may be explained because our cohort was high
functioning, or because we combined indoor and outdoor
falls in the analysis. Low adherence to medications may be
more prevalent among certain ethnic and racial groups (35)
or among persons with greater functional impairment com-
pared with individuals in our study, and poor adherence
may possibly be a greater risk factor for falls in these per-
sons.

In conclusion, older persons who report that they some-
times forget to take medications are at a greater risk of falls
compared with those who report better adherence. Future
studies should examine the association between poor adher-
ence with specific drug classes and falls and between rea-
sons for poor medication adherence and falls. It remains
unclear whether strategies to improve medication adherence
might decrease the frequency of falls, but clinicians should
screen for poor medication adherence as it is common and
predicts adverse health outcomes including falls.

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