ORIGINAL INVESTIGATION

Risk Factors for Adverse Drug Events Among Nursing Home Residents

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Background: In a prospective study of nursing home residents, we found adverse drug events (ADEs) to be common, serious, and often preventable. To direct prevention efforts at high-risk residents, information is needed on resident-level risk factors.

Methods: Case-control study nested within a prospective study of ADEs among residents in 18 nursing homes. For each ADE, we randomly selected a control from the same home. Data were abstracted from medical records on functional status, medical conditions, and medication use.

Results: Adverse drug events were identified in 410 nursing home residents. Independent risk factors included being a new resident (odds ratio [OR], 2.8; 95% confidence interval [CI], 1.5-5.2) and taking anti-infective medications (OR, 4.0; CI, 2.5-6.2), antipsychotics (OR, 3.2; CI, 2.1-4.9), or antidepressants (OR, 1.5; CI, 1.1-2.3). The number of regularly scheduled medications was associated with increased risk of ADEs; the OR associated with taking 5 to 6 medications was 2.0 (CI, 1.2-3.2); 7 to 8 medications, 2.8 (CI, 1.7-4.7); and 9 or more, 3.3 (CI, 1.9-5.6). Taking supplements or nutrients was associated with lower risk (OR, 0.42; CI, 0.27-0.63). Preventable ADEs occurred in 226 residents. Independent risk factors included taking opioid medications (OR, 6.6; CI, 2.3-19.3), antipsychotics (OR, 4.0; CI, 2.2-7.3), anti-infectives (OR, 3.0; CI, 1.6-5.8), antiepileptics (OR, 2.2; CI, 1.1-4.5), or antidepressants (OR, 2.0; CI, 1.1-3.5). Scores of 5 or higher on the Charlson Comorbidity Index were associated with increased risk of ADEs (OR, 2.6; CI, 1.1-6.0). The number of regularly scheduled medications was also a risk factor: the OR for 7 to 8 medications was 3.2 (CI, 1.4-6.9) and for 9 or more, 2.9 (CI, 1.3-6.8). Residents taking nutrients or supplements were at lower risk (OR, 0.27; CI, 0.14-0.50).

Conclusions: It is possible to identify nursing home residents at high risk of having an ADE. Particular attention should be directed at new residents, those with multiple medical conditions, those taking multiple medications, and those taking psychoactive medications, opioids, or anti-infective drugs.

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HIGH RATES of adverse events occur in the context of providing medical care in the United States, as documented by the Institute of Medicine's report *To Err is Human: Building a Safer Health System*.[1] Many of these events are adverse drug events (ADEs), defined to include preventable and nonpreventable events related to the use of medications. A series of studies[2,3] has examined ADEs in hospital settings. However, much less information is available about these events in nonacute settings. We recently examined the incidence and preventability of ADEs among the residents of 18 nursing homes during 1 year and found high rates of ADEs (1.89 ADEs per 100 resident-months, of which 0.96 were preventable).[4] This is not surprising, given the magnitude and intensity of drug use in nursing homes. Nursing home residents are frail, elderly, often have difficulty expressing and ascribing symptoms, and frequently suffer from multiple physical problems—a constellation of factors that may place them at special risk for developing problems related to their extensive drug regimens.

Documentation of the ADE problem in the acute care setting has led to a new focus on prevention within the health care system. Following examples from the aerospace industry,[5] medical safety is increasingly seen to require system-level modifications rather than more aggressive identification and punishment of those providers making errors. One system-level strategy for preventing ADEs in nursing homes may be to identify residents at high risk so that physicians can consider the resident's level of risk in their deci-

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SUBJECTS AND METHODS

The study was nested within a 12-month study of the incidence and preventability of ADEs in 18 nursing homes in central and eastern Massachusetts.[4] These facilities were recruited from among 81 nursing homes with more than 50 beds in this geographic region, which were served by a large long-term care pharmacy provider. The pharmacy provider assisted in the recruitment of the study nursing homes through invitational letters, telephone calls, and visits. The mean bed size of participating homes was 149 (SD, 62; range, 72-333). All were certified by Medicare and Medicaid. Sixty-one percent were proprietary, and the remainder were voluntary nonprofit nursing homes.

Nursing home enrollment in the study took place in the spring of 1997. Subjects included all long-stay residents of participating homes at any time during the 12-months following the facility's enrollment in the study. The study was approved by the institutional review board of the University of Massachusetts Medical School, Worcester.

Adverse drug events were defined as injuries resulting from use of a drug. *Preventable ADEs* were those that resulted from a medication error in prescribing, dispensing, administering, or monitoring. Nonpreventable ADEs are synonymous with adverse drug reactions, in which no error is involved. Drug-related incidents were identified through systematic medical chart reviews conducted at 6-week intervals by 3 investigators (2 nurses and a pharmacist) of each eligible nursing home resident in all study nursing homes. During medical chart reviews, investigators focused on several indicators of possible ADEs, including changes and discontinuations of prescribed medications; unusual laboratory values; changes in symptoms and new events such as lethargy, confusion, bleeding, falls, and gastrointestinal problems; and hospitalizations and emergency department visits. To assess the reliability of case investigators' identification of events, each investigator reviewed the same set of 10 medical chart components. All 3 investigators identified the same event in 9 of the 10 charts, with 1 investigator differing on 1 chart, for greater than 90% agreement. Investigators also encouraged nursing home staff to report any resident-related events that may have indicated an ADE, including incidents that may not have seemed immediately obvious as representing a drug-related event. Reports from nursing home staff accounted for 14% of the identified events.

Possible events were evaluated by 2 physician reviewers, who classified them independently as to whether they were ADEs. Classification as an ADE required an observable impact on the resident's health status or function. For all events classified as ADEs, reviewers also determined severity and preventability. Categories of severity were *significant*, *serious*, *life-threatening*, or *fatal*. Examples of significant events included falls without fracture, hemorrhage that did not require transfusion or hospitalization, oversedation, and rashes. Serious events included delirium, falls with fractures, and hemorrhages requiring transfusion or hospitalization without hypotension. Life-threatening events included hemorrhage with associated hypotension, hypoglycemic encephalopathy, and liver failure. Reviewers classified an ADE as preventable if it was due to an error and was preventable by any means currently available. Errors were defined according to the stage of pharmaceutical care (ordering, transcribing, dispensing, administering, or monitoring) and type. Errors occurred most commonly in the ordering and monitoring stages of care.[4]

Disagreements about classification were resolved during consensus meetings. Reviewers included 2 internist-geriatricians (J.H.G. and J.A.) and 2 general internists (D.M. and D.W.B.). To assess the reliability of event classification, 100 possible events were randomly drawn, evenly distributed across the 12 months of the study. The initial, preconsensus classifications of the 2 reviewers were compared, and percent agreement was 89% ($\kappa = 0.80$).

Cases included all residents who experienced an ADE during the study. For those residents with multiple ADEs, only the first ADE was included and all risk factor data were collected as of the date of that event. Among the 2916 subjects who were long-stay residents in participating nursing homes at some point during the study, ADEs were identified in 410. Of the initial events among these residents, 230 (56.1%) were classified as significant, 152 (37.1%) as serious, 27 (6.6%) as life-threatening, and 1 (0.2%) was

sions about prescribing, delivering, and monitoring drug therapy.[6] If predictive factors can be identified, they might also allow providers to identify early symptoms of adverse events and to respond to them quickly. Therefore, we performed a prospective study to assess whether resident-level factors are associated with ADEs and preventable ADEs among nursing home residents.

RESULTS

Altogether, 410 cases experienced an ADE. Age and sex were similar between the cases and controls. However, compared with their matched controls, residents with an ADE were significantly more likely ($P<.05$) to be new residents in the facility, to have a score of 5 or higher on the Charlson Comorbidity Index,[7] to take 5 or more regularly scheduled medications, and to be taking an antibiotic or anti-infective, anticoagulant, antidepressant, antiseizure drug, antipsychotic, cardiovascular drug, hypoglycemic, muscle relaxant, and a sedative or hypnotic (**Table 2**). Cases had higher scores on the Cumulative Illness Rating Scale[8] and were less likely to take nutrients or supplements.

To identify independent correlates of ADEs, we developed a multivariate model using backward stepwise conditional logistic regression. Possible problems with collinearity among variables in the model were assessed and none were found. Interactions were assessed and none were significant. Factors independently correlated with higher risk of an ADE (**Table 3**) were: being a new resident (OR, 2.8; CI, 1.5-5.2); taking 5 to 6 (OR, 2.0; CI, 1.2-3.2), 7 to 8 (OR, 2.8; CI, 1.7-4.7), or 9 or more (OR, 3.3; CI, 1.9-5.6) regularly scheduled medications; and taking an antibiotic or anti-infective (OR, 4.0; CI, 2.5-6.2), antipsychotic (OR, 3.2; CI, 2.1-4.9), or antidepressant (OR, 1.5; CI, 1.1-2.3). Taking nutrients or supplements was protective against ADEs (OR, 0.42; CI, 0.27-0.63).

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fatal. **Table 1** presents the event types: 115 (28.0%) included a neuropsychiatric component, 52 (12.7%) involved a fall, 49 (12.0%) had a dermatologic or allergic effect, 46 (11.2%) had an impact on the gastrointestinal system, 44 (10.7%) included hemorrhage, and 43 (10.5%) included extrapyramidal symptoms.

We analyzed preventable ADEs separately. For this portion of the study, cases included all residents who experienced a preventable event. Risk factor data were collected as of the date of the first preventable ADE. Of the 410 subjects with an ADE, 226 had at least 1 ADE that was classified as preventable. For those subjects whose preventable ADE was not the first event, new controls were randomly selected from residents present in the same nursing home at the time of the preventable ADE. Of the preventable ADEs, 86 (38.1%) were classified as significant, 116 (51.3%) as serious, 23 (10.2%) as life-threatening, and 1 (0.4%) was fatal. Sixty-five (28.8%) included a neuropsychiatric effect, 45 (19.9%) included a fall, 33 (14.6%) involved hemorrhage, and 25 (11.1%) included a gastrointestinal manifestation (Table 1).

For each case, a control was randomly selected from those long-stay residents present in the same facility on the date when the event occurred. Risk factor information was collected as of the date of the event for the case and control. All residents who had not yet had an ADE at the time of the event were eligible to serve as controls.

Information on potential risk factors for cases and controls was collected through medical chart review using standardized forms. Data included sex, age, and the length of time the resident had been in the facility (classified as a new resident if the date of admission was within 2 months of the event date). Burden of illness was assessed using the Charlson Comorbidity Index[7] (categorized using scoring as originally developed—0, 1-2, 3-4, and ≥5) and the Cumulative Illness Rating Scale[8] (as a continuous variable). Functional status was measured using the Activities of Daily Living scale[9] (categorized in quartiles) and the mobility item from the Tinetti Nursing Home Life-Space Diameter[10] (results were categorized as mobile or immobile). Information on medication use at the time of the event included the number of regularly scheduled medications (categorized in quartiles) and use of any drug within each of the following drug classes: Alzheimer disease treatments, antibiotics or anti-infectives, anticoagulants, antidepressants, antigout therapy, antihistamines, antihyperlipidemics, antineoplastics, antiparkinsonians, antipsychotics, antiseizure medications, cardiovascular drugs, cholesterol lowering drugs, diuretics, gastrointestinal medications, hypoglycemics, muscle relaxants, nonophthalmic topical medications, nonopioid analgesics, nutrients or supplements, ophthalmics, opioids, osteoporosis medications, respiratory medications, sedatives or hypnotics, steroids, and thyroid medications. Reliability of medical chart reviews was assessed through a chart extraction by all 3 investigators on a set of 10 charts. Agreement was 90% or greater on the presence of comorbid conditions for each condition, on the current use of each drug category, and on subjects' abilities to carry out 4 of the activities of daily living. There was more frequent disagreement for 2 of the activities, feeding and continence.

Analyses began with the calculation of matched odds ratios (ORs) and *P* values for each categorical variable and paired *t* tests for the continuous variables of age and the Cumulative Illness Rating Scale[8] score. Subsequently, separate multivariate models were constructed using all ADEs and preventable ADEs as the outcome with stepwise conditional logistic regression using commercially available statistical software.[11] Variables considered for inclusion were those that were significantly associated with case or control status at $P \leq .05$ and with prevalence of at least 5% in either the case or control group. Correlations among potential risk factors were assessed, and any correlated variables were analyzed in separate models. Age and sex were forced into all models. Variables were retained in the model if they were found to have $P \leq .05$. We assessed interactions in the optimum models.

Models were built using the categorized Charlson Comorbidity Index[7] and the individual diseases from that index. The performance of the version with the categorized index was superior, so that version was retained. We hypothesized that 3 particular conditions in the Charlson Comorbidity Index (dementia, liver disease, and renal disease) may place the residents at special risk for ADEs,[12] and we included them in our analyses.

We also performed univariate analyses to identify variables correlated with the presence of a preventable ADE (**Table 4**). Residents with preventable ADEs were significantly more likely to be a new resident in the home, to have a score of 5 or higher on the Charlson Comorbidity Index,[7] to take 5 or more regularly scheduled medications, and to take antibiotics or anti-infectives, anticoagulants, antidepressants, antiseizure medications, antipsychotics, cardiovascular drugs, hypoglycemics, opioids, and sedatives or hypnotics. They also had higher scores on the Cumulative Illness Rating Scale[8] and were less likely to be immobile or to take nutrients or supplements.

Independent predictors of a preventable ADE were then identified using backward stepwise conditional logistic regression (**Table 5**). Variables independently associated with having a preventable ADE included having a score of 5 or higher on the Charlson Comorbidity Index[7] (OR, 2.6; CI, 1.1-6.0), taking 7 to 8 (OR, 3.2; CI, 1.4-6.9) or 9 or more (OR, 2.9; CI, 1.3-6.8) regularly scheduled medications, and taking an antibiotic or anti-infective (OR, 3.0; CI, 1.6-5.8), antidepressant (OR, 2.0; CI, 1.1-3.5), antipsychotic (OR, 4.0; CI, 2.2-7.3), antiseizure drug (OR, 2.2; CI, 1.1-4.5), or opioid (OR, 6.6; CI, 2.3-19.3). Residents taking nutrients or supplements were at lower risk (OR, 0.27; CI, 0.14-0.50). Men were less likely than women were to have a preventable ADE (OR, 0.55; CI, 0.30-0.99).

COMMENT

We found several resident-level factors to be associated with ADEs and preventable ADEs, and these correlations were much stronger than they appear to be in the inpatient setting.[6] Some of these factors may be modifiable; in particular, greater numbers of regularly scheduled medications, antibiotics, and psychoactive drugs were strongly associated with occurrence of ADEs and pre-

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Table 1. Adverse Drug Event (ADE) Types*

	All ADEs (n = 410)	Preventable ADEs (n = 226)
Anorexia/weight loss	19 (4.6)	13 (5.8)
Anticholinergic	1 (0.2)	0
Ataxia/gait difficulty	13 (3.2)	8 (3.5)
Cardiovascular	10 (2.4)	9 (4.0)
Dermatologic/allergic	49 (12.0)	7 (3.1)
Electrolyte/fluid balance abnormality	4 (1.0)	4 (1.8)
Extrapyramidal syndrome/tardive dyskinesia	43 (10.5)	16 (7.1)
Falls	52 (12.7)	45 (19.9)
Functional decline	5 (1.2)	6 (2.7)
Gastrointestinal	46 (11.2)	25 (11.1)
Hematologic	2 (0.5)	2 (0.9)
Hemorrhage	44 (10.7)	33 (14.6)
Hepatic	1 (0.2)	1 (0.4)
Infection	22 (5.4)	0
Metabolic/endocrine	17 (4.1)	10 (4.4)
Neuropsychiatric	115 (28.0)	65 (28.8)
Renal	2 (0.5)	1 (0.4)
Respiratory	3 (0.7)	3 (1.3)
Syncope	7 (1.7)	5 (2.2)

*Data are given as number (percentage). Events may include more than 1 type.

ventable ADEs. New residents were at high risk of having an ADE, but this factor did not attain significance in the multivariate analysis of risk factors for preventable ADEs ($P = .08$). Opioids and antiseizure medications were associated only with preventable ADEs, as was the number of chronic conditions.

Adverse drug events are a serious problem in the nursing home setting. Our assessment of the incidence of ADEs in nursing homes found a rate of 1.89 per 100 resident-months, with approximately one half judged to be preventable.[4] These events had substantial impact on residents, with manifestations that included delirium, lethargy, falls, and hemorrhage.

Although many risk factors have been proposed as being associated with the occurrence of ADEs, relatively little empiric evidence is available, especially for preventable ADEs.[6] The findings of this study—that many variables are strongly associated with ADEs in the nursing home setting—contrast remarkably with those of a large recent study[6] conducted in inpatients, which found few patient-level correlates. Among the potential reasons for this is that there may be more heterogeneity in the level of illness among residents in nursing homes and that the degree of oversight is much less intense. The drug regimens of nursing home residents are frequently of long duration and are administered in the context of frequent changes in physiologic status.

The intent of this study was to better define resident-level factors associated with high risk of ADEs, with the ultimate goal of supporting interventions that prevent ADEs and lessen their impact. In the nursing home environment, physicians may be physically distant from residents, but nursing and support staff are in daily direct contact. Clearly identifiable factors such as the type and number of medical conditions and drugs can be easily tracked and built into monitoring systems for physicians, nurses, and pharmacists.

Table 2. Characteristics of Residents With Adverse Drug Events and Controls*

	Cases (n = 410)	Controls (n = 410)	*P*
Age, mean (SD), y	83.8 (8.3)	84.3 (9.0)	.42
Cumulative Illness Rating Scale,[8] mean (SD)	11.5 (3.6)	10.8 (3.3)	<.01
Male	103 (25.1)	98 (23.9)	.69
New resident	70 (17.1)	25 (6.1)	<.01
Activities of Daily Living scale[9]			
High function (0-5)	94 (22.9)	93 (22.7)	Referent
Mid function (6-8)	116 (28.3)	112 (27.3)	.48
Mid/low function (9-10)	124 (30.2)	122 (29.8)	.34
Low function (≥11)	76 (18.5)	83 (20.2)	.61
Immobile	36 (8.8)	53 (12.9)	.35
Charlson Comorbidity Index[7] score			
0	22 (5.4)	43 (10.5)	.17
1-2	200 (48.8)	223 (54.4)	Referent
3-4	125 (30.5)	103 (25.1)	.63
≥5	63 (15.4)	41 (10.0)	.01
Specific chronic conditions			
Dementia	244 (59.5)	237 (57.8)	.62
Liver disease	4 (1.0)	8 (2.0)	.24
Renal disease	9 (2.2)	5 (1.2)	.28
No. of regularly scheduled medications			
0-4	69 (16.8)	147 (35.9)	Referent
5-6	93 (22.7)	97 (23.7)	<.01
7-8	101 (24.6)	78 (19.0)	.02
≥9	147 (35.9)	88 (21.5)	<.01
Current medications			
Alzheimer disease treatments	8 (2.0)	5 (1.2)	.41
Antibiotics/anti-infectives	142 (34.6)	57 (13.9)	<.01
Anticoagulants	74 (18.0)	47 (11.5)	.01
Antidepressants	194 (47.3)	149 (36.3)	<.01
Antigout drugs	17 (4.1)	11 (2.7)	.26
Antihistamines	12 (2.9)	10 (2.4)	.66
Antineoplastics	10 (2.4)	5 (1.2)	.20
Antiparkinsonians	43 (10.5)	28 (6.8)	.07
Antipsychotics	140 (34.1)	71 (17.3)	<.01
Antiseizure drugs	80 (19.5)	53 (12.9)	.01
Cardiovascular drugs	242 (59.0)	201 (49.0)	<.01
Cholesterol lowering drugs	12 (2.9)	8 (2.0)	.37
Diuretics	159 (38.8)	143 (34.9)	.23
Gastrointestinal drugs	314 (76.6)	308 (75.1)	.62
Hypoglycemics	75 (18.3)	42 (10.2)	<.01
Muscle relaxants	27 (6.6)	14 (3.4)	.03
Nonophthalmic topicals	7 (1.7)	2 (0.5)	.10
Nonopioid analgesics	273 (66.6)	258 (62.9)	.27
Nutrients/supplements	242 (59.0)	280 (68.3)	<.01
Ophthalmics	62 (15.1)	49 (12.0)	.19
Opioids	39 (9.5)	28 (6.8)	.16
Osteoporosis drugs	20 (4.9)	12 (2.9)	.16
Respiratory drugs	40 (9.8)	32 (7.8)	.33
Sedatives/hypnotics	137 (33.4)	97 (23.7)	<.01
Steroids	39 (9.5)	31 (7.6)	.31
Thyroid drugs	71 (17.3)	53 (12.9)	.08
Miscellaneous drugs	31 (7.6)	30 (7.3)	.89

*Data are given as number (percentage) unless otherwise indicated. Some percentages do not sum to 100 because of rounding.

A major risk factor for ADEs identified in our study was the number of regularly scheduled medications. Previous studies[13-22] have found the number of drugs to be a risk factor for several drug problems in older adults,

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Table 3. Independent Risk Factors for Having an Adverse Drug Event

Risk Factor	Odds Ratio* (95% Confidence Interval)
New resident (1st or 2nd month)	2.8 (1.5-5.2)
No. of regularly scheduled medications	
<5	1.0 (Referent)
5-6	2.0 (1.2-3.2)
7-8	2.8 (1.7-4.7)
≥9	3.3 (1.9-5.6)
Current medications	
Antibiotics/anti-infectives	4.0 (2.5-6.2)
Antipsychotics	3.2 (2.1-4.9)
Antidepressants	1.5 (1.1-2.3)
Nutrients/supplements	0.42 (0.27-0.63)

*Adjusted for age and sex.

although this was not an independent factor in a recent study[6] of hospitalized patients of all ages. Among residents of long-term care facilities, 2 studies[13,14] have found the number of drugs to be significantly associated with having an adverse drug reaction. Most studies performed among community-dwelling[15-20] and hospitalized[21,22] older populations have also identified the number of drugs to be predictive of ADEs, with 2 studies[23,24] reporting conflicting results.

Our finding that the number of chronic conditions was associated with ADEs is also consistent with several previous studies of older adults.[16,19,20,23,25] Counts of medical problems and number of drugs taken are usually correlated. A previous study[23] that controlled for both factors simultaneously through multivariate modeling found only the number of medical diagnoses to be a significant predictor of ADEs. In this study, both factors were independently associated with preventable ADEs.

We found that residents taking drugs within several specific classes were at higher risk of having an ADE. Our analyses of the relationship between drug classes and ADEs did not focus on identifying drugs that were directly responsible for events. Rather, we were interested in using drugs as markers to identify residents at high risk by comparing the drug use patterns of residents who experienced ADEs with those of residents who did not have an event. In such an analysis, drugs may be serving as proxies for the underlying medical or functional condition that they are prescribed to treat, or they may be acting as promoters of reactions to other medications. One example of this is our finding of a lower risk among residents taking nutrients or supplements. Use of these agents may be a proxy for the resident's health and functional status or the caretaking approach of providers. Several of the drugs that we found associated with ADEs have been highlighted elsewhere[14,26] as having a direct association with drug-related problems, including psychoactive medications and opioids. However, antibiotics and antiseizure drugs are rarely pinpointed as risk factors.

These data have several implications for prevention of ADEs. First, the number of medications given should be minimized and indications reviewed regularly. Initiation of drugs, especially antibiotics, should be carefully considered as these medications are not innocuous and some use may be unnecessary. Perhaps the most exciting possibility is to combine these factors, many of which are standard tenets of geropharmacology, and use them to target populations at greatest need for increased levels of scrutiny.

Table 4. Characteristics of Residents With Preventable Adverse Drug Events and Controls*

	Cases (n = 226)	Controls (n = 226)	*P*
Age, mean (SD), y	84.2 (7.6)	84.1 (9.2)	.90
Cumulative Illness Rating Scale,[8] mean (SD)	11.6 (3.8)	11.0 (3.4)	.03
Male	59 (26.1)	58 (25.7)	.92
New resident	34 (15.0)	13 (5.8)	<.01
Activities of Daily Living scale[9]			
High function (0-5)	55 (24.3)	53 (23.5)	Referent
Mid function (6-8)	65 (28.8)	54 (23.9)	.72
Mid/low function (9-10)	68 (30.1)	70 (31.0)	.86
Low function (≥11)	38 (16.8)	49 (21.7)	.47
Immobile	16 (7.1)	31 (13.7)	.02
Charlson Comorbidity Index[7] score			
0	8 (3.5)	22 (9.7)	.20
1-2	107 (47.3)	118 (52.2)	Referent
3-4	72 (31.9)	61 (27.0)	.54
≥5	39 (17.3)	25 (11.1)	.03
Specific chronic conditions			
Dementia	138 (61.1)	135 (59.7)	.77
Liver disease	3 (1.3)	5 (2.2)	.48
Renal disease	5 (2.2)	5 (2.2)	1.00
No. of regularly scheduled medications			
0-4	36 (15.9)	85 (37.6)	Referent
5-6	50 (22.1)	56 (24.8)	<.01
7-8	60 (26.5)	34 (15.0)	.02
≥9	80 (35.4)	51 (22.6)	.01
Current medications			
Alzheimer disease treatments	5 (2.2)	4 (1.8)	.74
Antibiotics/anti-infectives	65 (28.8)	32 (14.2)	<.01
Anticoagulants	50 (22.1)	31 (13.7)	.02
Antidepressants	115 (50.9)	79 (35.0)	<.01
Antigout drugs	12 (5.3)	5 (2.2)	.09
Antihistamines	7 (3.1)	3 (1.3)	.21
Antineoplastics	7 (3.1)	2 (0.9)	.10
Antiparkinsonians	18 (8.0)	18 (8.0)	1.00
Antipsychotics	85 (37.6)	42 (18.6)	<.01
Antiseizure drugs	49 (21.7)	26 (11.5)	<.01
Cardiovascular drugs	139 (61.5)	116 (51.3)	.04
Cholesterol lowering drugs	6 (2.7)	3 (1.3)	.32
Diuretics	98 (43.4)	85 (37.6)	.21
Gastrointestinal drugs	169 (74.8)	170 (75.2)	.91
Hypoglycemics	42 (18.6)	19 (8.4)	<.01
Muscle relaxants	15 (6.6)	9 (4.0)	.22
Nonophthalmic topicals	4 (1.8)	1 (0.4)	.18
Nonopioid analgesics	130 (57.5)	157 (69.5)	.01
Nutrients/supplements	140 (619)	143 (63.3)	.77
Opthalmics	30 (13.3)	30 (13.3)	1.00
Opioids	25 (11.1)	10 (4.4)	.01
Osteoporosis drugs	11 (4.9)	7 (3.1)	.35
Respiratory drugs	21 (9.3)	22 (9.7)	.88
Sedatives/hypnotics	83 (36.7)	49 (21.7)	<.01
Steroids	23 (10.2)	18 (8.0)	.42
Thyroid drugs	34 (15.0)	36 (15.9)	.79
Miscellaneous drugs	20 (8.8)	12 (5.3)	.13

*Data are given as number (percentage) unless otherwise indicated. Some percentages do not sum to 100 because of rounding.

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Table 5. Independent Risk Factors for Having a Preventable Adverse Drug Event

Risk Factor	Odds Ratio* (95% Confidence Interval)
Male	0.55 (0.30-0.99)
Charlson Comorbidity Index[7] score	
0	0.43 (0.14-1.3)
1-2	1.0 (Referent)
3-4	1.6 (0.88-2.9)
≥5	2.6 (1.1-6.0)
No. of regularly scheduled medications	
0-4	1.0 (Referent)
5-6	1.7 (0.83-3.5)
7-8	3.2 (1.4-6.9)
≥9	2.9 (1.3-6.8)
Current medications	
Antibiotics/anti-infectives	3.0 (1.6-5.8)
Antidepressants	2.0 (1.1-3.5)
Antipsychotics	4.0 (2.2-7.3)
Antiseizure drugs	2.2 (1.1-4.5)
Nutrients/supplements	0.27 (0.14-0.50)
Opioids	6.6 (2.3-19.3)

*Adjusted for age.

The study had several limitations. The size of the resident population included in the study and the resulting number of ADEs and preventable ADEs limited our ability to identify risk factors to moderate-sized risks associated with factors present in a substantial portion of the population. The study was based in 18 nursing homes in a specific geographic area. It is possible that physician prescribing and nursing care patterns specific to this region could have colored our results. The approach we used to identify and classify ADEs and preventable ADEs was based on medical record review, followed by extensive review sessions and independent classification by 2 physicians. Only those events classified as ADEs with a high confidence level were included. This limited events to those with high probability and undoubtedly excluded many actual drug-related problems. Thus, our findings may be biased toward risk factors for easily identifiable events that are definitely the result of medication use. In addition, we have not prospectively validated these results, and the factors may be less predictive in an independent cohort.[27]

Based on our findings, we recommend that physicians prescribing medications in nursing homes pay special attention to drug choices in residents with multiple medical conditions and extensive drug regimens and increase surveillance of those residents using psychoactive drugs. Nursing staff should carefully monitor these high-risk residents and those taking antibiotics, opioids, or antiseizure drugs to identify changes in symptoms that may indicate a drug-related event.

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