RESEARCH BRIEF

Prevalence of Potentially Inappropriate Medication Use in Older Drivers: AAA LongROAD Study

Use of potentially inappropriate medications (PIMs) in older adults is associated with high levels of morbidity, mortality and health care expenditures. The Beers Criteria are a widely used tool for identifying PIMs that should generally be avoided in older adults. The American Geriatrics Society 2015 Beers Criteria were applied to baseline data collected from a "brown-bag" review of medications for the Longitudinal Research on Aging Drivers (LongROAD) participants to examine the prevalence and correlates of PIM use. Overall, 18.5% of the study sample used at least one PIM. The most commonly used therapeutic category of PIM was benzodiazepines (accounting for 16.6% of the total PIMs identified), followed by nonbenzodiazepine hypnotics (16.4%), antidepressants (15.2%) and first-generation antihistamines (10.5%). The variable most predictive of PIM use was the total number of medications being taken. Other factors associated with a significantly increased use of PIMs were being female, being white and living in an urban residence. Use of PIMs is fairly common in older drivers and often involves medications known to impair driving ability and increase crash risk. In order to improve traffic safety among older drivers, drivers should be aware of the types of medications they are taking to ensure optimal safety behind the wheel.

METHODS

Information presented in this document used data from the LongROAD project — a multisite prospective cohort study of 2,990 active drivers ages 65–79 years old, from primary care clinics or health care systems in five study sites (Ann Arbor, Michigan; Baltimore, Maryland; Cooperstown, New York; Denver, Colorado; and San Diego, California). The study design and research protocol for the LongROAD project is described in detail in another publication by Li et al. (2017). Following informed consent, each driver was assessed at baseline with standardized research protocols and instruments, which included functional performance tests, a questionnaire interview and a brown-bag review of medications, in which research staff instructed the study participants to bring all current medications (both prescribed and over-the-counter) and supplements.

Medication data collected at baseline were coded according to the pharmacologic/therapeutic classification system established by the American Society of Health-System Pharmacists in the American Hospital Formulary Service (AHFS) Clinical Drug Information (ASHP, 2017). The AHFS classification system groups medications with similar pharmacologic, therapeutic and chemical characteristics in a four-tier hierarchy (ASHP, 2017). Baseline medication data were available for 2,949 (98.6%) of the 2,990 study participants. A total of 24,690 medications were recorded from the brown-bag review at baseline; 22,856 (92.6%) were coded successfully with the AHFS classification system. Noncoded medications included foodlike items (e.g., spices or protein), homeopathic products and other supplements (e.g., witch hazel, zinc) (Hill et al., 2018).

The 2015 American Geriatrics Society (AGS) Beers Criteria for PIM use in older adults were applied to the AHFS-coded medication data to identify PIMs in the study sample. Where necessary, diagnosis data from the study participant's medical records and self-reported health conditions were reviewed to confirm that the criteria specified in the 2015 AGS Beers Criteria were met. Included in the analysis were PIMs that should generally be avoided.

Prevalence of PIM use was calculated according to demographic characteristics. A three-category variable measuring frailty was created based on the frailty score: 0, not frail; 1–2, prefrail; and 3–5, frail (Fried et al., 2001). The frailty score is defined as the number of five symptoms present in a given study participant (Table 1).

The prevalence of PIM use was also analyzed in relation to the residence locations of LongROAD participants. The rural-urban commuting area (RUCA) codes were derived from the study participants' home address ZIP codes: urban (RUCA codes 1 and 1.1 (metropolitan core)); suburban (RUCA codes 2, 2.1 and 3 (metropolitan area noncore)); and rural (RUCA codes 4-10 (metropolitan, small towns or rural)). Differences in the prevalence of PIM use across variables were assessed with chi-square tests, adjusted odds ratios (ORS) and 95% confidence intervals (CIs). Associations of PIM use with sociodemographic variables were estimated from a multivariable logistic regression model.

Table 1: Frailty Score by Symptom

Frailty Score	Five Symptoms in a Given Participant
1	Unintentional weight loss (≥4.5 kg in the past year)
2	Exhaustion ("I felt that everything I did was an effort" and "I could not get going" in the last seven days)
3	Low physical activity (having not walked for exercise or engaged in vigorous physical activity recently)
4	Weakness (grip strength in the lowest quintile of the study sample)
5	Slow walking speed (gait speed for 15 feet adjusted for sex and height in the lowest quintile of the study sample)

RESULTS

Overall, 545 out of the 2,949 study participants with medication data available used at least one PIM that should generally be avoided, yielding a point prevalence of 18.5%. The prevalence of PIM use varied significantly with age, sex, race/ethnicity and marital status (Table 2). Specifically, higher prevalence of PIM use was found in drivers who were 75–79 years of age, female, white or not currently married (Table 2). The most pronounced difference in the prevalence of PIM use with regard to demographic characteristics was between sexes, with female drivers being nearly twice as likely as male drivers to use PIMs (23.8% vs. 12.4%, $p<0.0001$). PIM use was not significantly associated with education and household income levels.

When measured by frailty score, the health status of the study participants was mostly good, with 41.2% being classified as not frail, 55.9% as prefrail, and 2.9% as frail. The prevalence of PIM use for those in the "not frail" group was 17.8%, which increased to 18.5% in the "prefrail" group and 24.7% in the "frail" group ($p = 0.286$; Table 2). Additionally, the prevalence of PIM use varied with study sites, ranging from 14.8% for drivers recruited in Cooperstown, New York, to 21.9% for drivers recruited in San Diego, California (Table 2).

Almost three-quarters (72.8%) of the drivers studied were living in urban areas, 14.0% in suburban areas and 13.2% in rural areas. The prevalence of PIM use among older drivers in urban areas was 20.1%, significantly higher than in suburban areas (13.6%) and rural areas (14.7%) ($p = 0.001$; Figure 1). The prevalence of PIM use increased progressively with the number of medications used. Over one-third (34.3%) of older drivers who were on 12 or more medications used PIMs, compared with 6.0% of those on four or fewer medications, 13.4% of those on five to seven medications and 21.4% of those on eight to 11 medications ($p<0.001$; Figure 2).

Multivariable logistic regression modeling revealed that the total number of medications used was strongly associated with PIM use. For example, relative to older drivers on four or fewer medications, patients on five to seven medications were more than twice (2.43) as likely to be using PIMs; patients on eight to 11 medications were more than four times

(4.19) as likely to be using PIMs, and those using 12 or more medications were eight times more likely to be using PIMs. Other variables significantly associated with PIM use were sex, race/ethnicity and location of residence. Specifically, drivers who were female, white or living in urban areas showed significantly increased risk of PIM use (Table 3). There were no significant interaction effects on PIM use between these variables.

The use of multiple PIMs was fairly common among older drivers. Of the 545 PIM users, 95 (17.4%) used two or more PIMs. The most frequently used therapeutic category of PIM was benzodiazepines (e.g., Diazepam or Valium typically used to treat anxiety, insomnia and seizures, and to relax the muscles), accounting for 16.6% of the total PIMs identified. Other frequently used PIMs were nonbenzodiazepine hypnotics (e.g., eszopiclone, zolpidem and zalepon, which have similar side effects and risk of benzodiazepines but a different chemical structure; 16.4%), antidepressants (e.g., amitriptypine and clomipramine; 15.2%), first-generation antihistamines (e.g., chlorpheniramine and diphenhydramine; 10.5%), estrogens (oral and topical; 10.4%), skeletal muscle relaxants (e.g., carisoprodol and metaxalone; 8.6%), and NSAIDs (e.g., ibuprofen and naproxen; 7.4%) (Table 4). Together, these therapeutic categories accounted for 85.1% of the total PIMs.

DISCUSSION

In summary, the information presented in this paper provides valuable empirical evidence for understanding the magnitude of PIMs in older drivers and sheds light on the factors associated with PIM use and the specific medications involved. The odds of PIM use increase with the number of medications taken and are particularly high among white, female older drivers in urban areas. The PIMs most commonly used by older drivers are benzodiazepines, nonbenzodiazepine hypnotics, antidepressants and first-generation antihistamines, all of which have been linked to driving impairment and increased crash risk. Implementation of evidence-based interventions, such as computer-based alerts and restrictive prescription rules (Bourcier et al., 2018), may reduce PIM use and improve health outcomes and driving safety in older adults. Previous studies (Sheikh-Taha and Dimassi, 2017; Komagamine, 2018; Patel et al., 2018) have identified several demographic and clinical characteristics associated with PIM use, including age, sex, race, health status and total number of medications used. Study results showed that because LongROAD participants included in these analyses had favorable health status, there was no statistical significance among age and health status (measured by frailty status) with PIM use. As the participants grow older and frailer, the associations of advancing age and declining health status with PIM use may become more evident.

The PIMs included in the 2015 AGS Beers Criteria should generally be avoided in older adults because they are therapeutically ineffective or pose an exceptionally high risk of adverse effects, such as delirium, internal bleeding and injury resulting from falls. The LongROAD study provides detailed data on PIMs used by older drivers. Most of the commonly used PIMs identified in this work, such as benzodiazepines, nonbenzodiazepine hypnotics, antidepressants and first-generation antihistamines, are medications known to impair driving performance and increase crash risk (Verster et al., 2004; Dassanayake et al., 2011; Rudisill et al., 2016; Hill et al., 2017). Meta-analyses carried out by other researchers (Dassanayake et al., 2011; Rudisill et al., 2016) have shown that the use of benzodiazepines is associated with a 60–80% increased risk of crash involvement and 40% increased risk of crash culpability and that older adults are particularly susceptible to the deleterious effect of antidepressants on driving safety.

It is important to note that the Beers Criteria are a clinical tool designed to identify and evaluate potentially inappropriate medications that should generally be avoided in older adults. Such criteria are necessary because there might be a clinical circumstance under which the use of a PIM is valid. The prevalence of PIMs reported in this study is likely a conservative estimate because the analysis excluded proton-pump inhibitors (i.e. medications that reduce stomach acid production) and was restricted to PIMs that should be avoided in older adults.

To better understand the trajectory of PIM use during the process of aging and the relationships between PIM use and driving outcomes (such as safety behavior and crash risk) future research should incorporate follow-up data.

The LongROAD study offers the opportunity to examine the number and specific type of medications used among a vulnerable population. Having knowledge of these types of medications, as well as their side effects, could enhance traffic safety.

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ABOUT AAA FOUNDATION FOR TRAFFIC SAFETY

The AAA Foundation for Traffic Safety is a 501(c)(3) nonprofit, publicly supported charitable research and education organization. It was founded in 1947 by the American Automobile Association to conduct research to address growing highway safety issues. The organization's mission is to identify traffic safety problems, foster research that seeks solutions, and disseminate information and educational materials. AAA Foundation funding comes from voluntary, tax-deductible contributions from motor clubs associated with the American Automobile Association and the Canadian Automobile Association, individual AAA club members, insurance companies and other individuals or groups.

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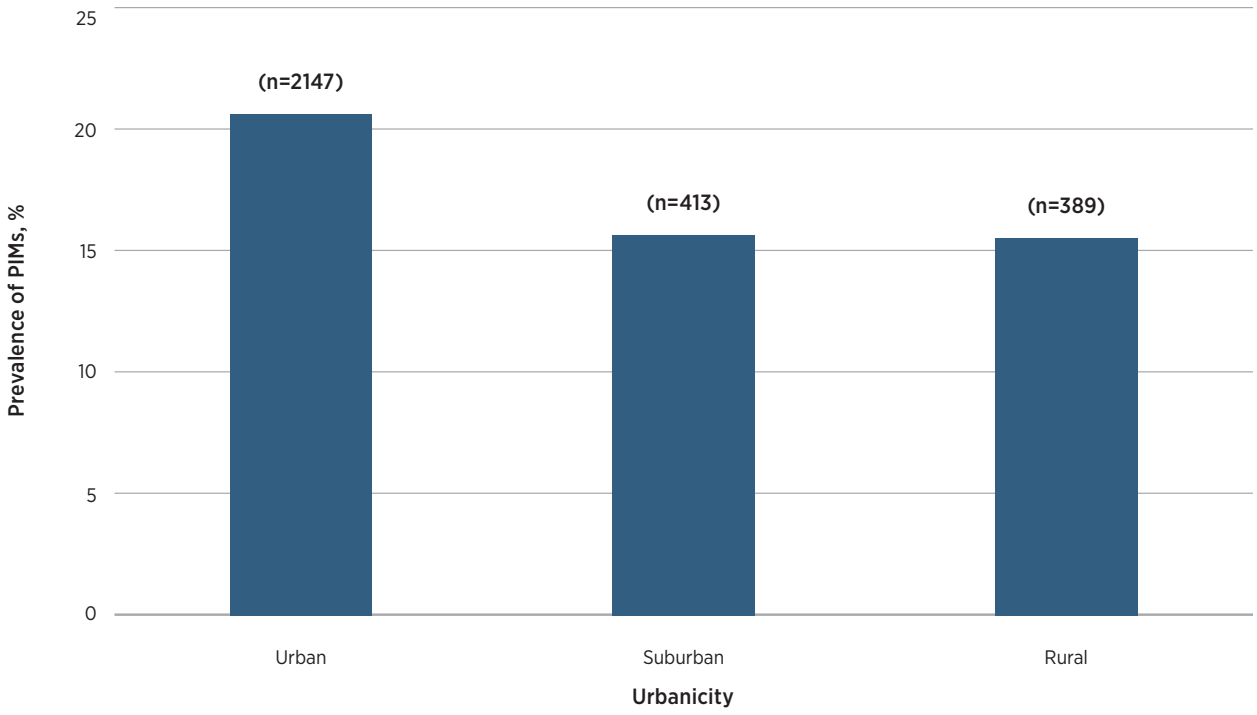

Figure 1. Prevalence of Potentially Inappropriate Medication (PIM) Use by Urbanicity in Older Drivers

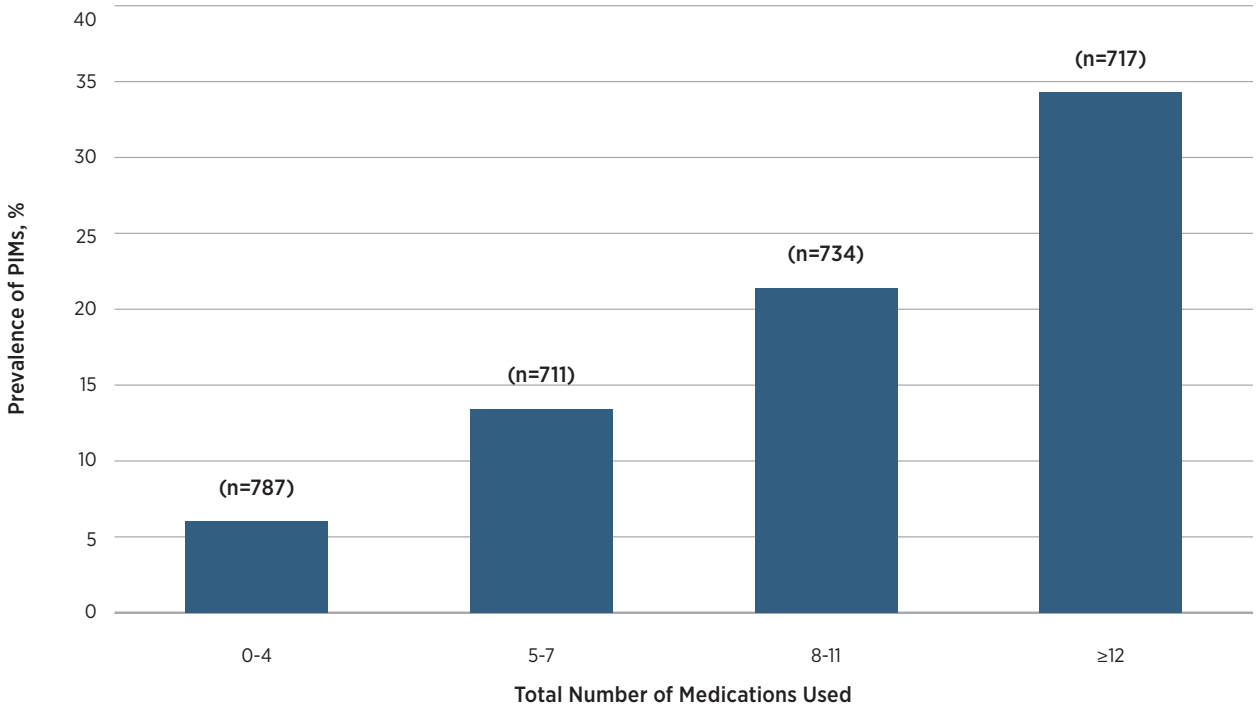

Figure 2. Prevalence of Potentially Inappropriate Medication (PIM) Use by Total Number of Medications Used in Older Drivers

Table 2. Prevalence of Potentially Inappropriate Medication (PIM) Use in Older Drivers by Demographic Characteristics

Characteristic	No. of Drivers	No. of Drivers Using One or More PIM[a]	Prevalence (%)	P Value
Overall	2949	545	18.5	
Age at Baseline (years)				**0.244**
65–69	1222	225	18.4	
70–74	1027	177	17.2	
75–79	700	143	20.4	
Sex				**0.000**
Male	1382	172	12.4	
Female	1567	373	23.8	
Race/Ethnicity				**0.004**
White, non-Hispanic	2526	491	19.4	
Black, non-Hispanic	207	24	11.6	
Hispanic	80	15	18.8	
Asian	65	5	7.7	
Other	71	10	14.1	
Marital Status				**0.003**
Married	1850	307	16.6	
Divorced	439	105	23.9	
Widowed	371	81	21.8	
Never married	128	23	18.0	
Other	161	29	18.0	
Education				**0.248**
Less than high school	70	13	18.6	
High school	265	43	16.2	
Some college	715	152	21.3	
Bachelor's degree	691	126	18.2	
Advanced degree	1208	211	17.5	
Household Income in the previous year				**0.332**
<$20,000	131	31	23.7	
$20,000–$49,999	633	118	18.6	
$50,000–$79,999	710	133	18.7	
$80,000–$99,999	427	67	15.7	
≥100,000	942	174	18.5	
Frailty score				**0.286**
Not frail	1205	215	17.8	
Pre-frail	1636	302	18.5	
Frail	85	21	24.7	

[a] Includes 450 drivers using one PIM, 76 using two PIMs, 15 using three PIMs, three using four PIMs and one using five PIMs.

Table 2. ***cont.*** Prevalence of Potentially Inappropriate Medication (PIM) Use in Older Drivers by Demographic Characteristics

Characteristic	No. of Drivers	No. of Drivers Using One or More PIM[a]	Prevalence (%)	P Value
Overall	2949	545	18.5	
Study Site				**0.005**
Ann Arbor, MI	595	102	17.1	
Baltimore, MD	583	100	17.2	
Cooperstown, NY	595	88	14.8	
Denver, CO	577	124	21.5	
San Diego, CA	599	131	21.9	

[a] Includes 450 drivers using one PIM, 76 using two PIMs, 15 using three PIMs, three using four PIMs and one using five PIMs.

Table 3. Adjusted Odds Ratios and 95% Confidence Intervals of Potentially Inappropriate Medication (PIM) Use in Older Drivers by Demographic Characteristics

Driver Characteristic	Odds Ratio	95% CI
Age at Baseline (years)		
65–69	1.00	
70–74	0.87	0.69–1.10
75–79	0.99	0.77–1.28
Sex		
Male	1.00	
Female	2.05	1.65–2.55
Race/Ethnicity		
White, non-Hispanic	1.00	
Black, non-Hispanic	0.42	0.26–0.66
Hispanic	0.86	0.47–1.58
Asian	0.36	0.14–0.92
Other	0.61	0.30–1.22
Marital Status		
Married	1.00	
Divorced	1.24	0.94–1.63
Widowed	1.06	0.78–1.44
Never married	0.94	0.58–1.55
Other	1.13	0.73–1.77
Frailty score		
Not frail	1.00	
Pre-frail	0.90	0.73-1.10
Frail	1.01	0.58-1.75
Total number of medications used		
0–4	1.00	
5–7	2.43	1.68–3.51
8–11	4.19	2.95–5.93
≥12	8.01	5.71-11.23
Urbanicity		
Rural	1.00	
Suburban	0.90	0.60–1.37
Urban	1.61	1.17–2.21

Table 4. Frequency of Potentially Inappropriate Medications by Therapeutic Category in Older Drivers

Therapeutic Category	Frequency[a]	Percent
Benzodiazepines	110	16.6
Nonbenzodiazepine Hypnotics	109	16.4
Antidepressants	101	15.2
First-Generation Antihistamines	70	10.5
Estrogens (Oral and Patch)	69	10.4
Skeletal Muscle Relaxants	57	8.6
NSAIDs (Oral)	49	7.4
Antispasmodics	33	5.0
Antipsychotics	16	2.4
Sulfonylureas (Long duration)	11	1.6
Other[b]	39	5.9
Total	**664**	**100.0**

[a] Includes 450 drivers using one PIM, 76 using two PIMs, 15 using three PIMs, three using four PIMs and one using five PIMs.
[b] Includes nine drivers on barbiturates, six on dronedarone, six on insulin (sliding scale), four on nitrofurantonin, three on androgens, three on metoclopramide, three on desmopressin, two on peripheral alpha-1 blockers, two on mineral oil (oral) and one on antiparkinsonian agents.