

Age and Sex Patterns of Drug Prescribing in a Defined American Population

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Abstract

Objective: To describe the age and sex patterns of drug prescribing in Olmsted County, Minnesota.

Patients and Methods: Population-based drug prescription records for the Olmsted County population in 2009 were obtained using the Rochester Epidemiology Project medical records linkage system (n=142,377). Drug prescriptions were classified using RxNorm codes and were grouped using the National Drug File—Reference Terminology.

Results: Overall, 68.1% of the population (n=96,953) received a prescription from at least 1 drug group, 51.6% (n=73,501) received prescriptions from 2 or more groups, and 21.2% (n=30,218) received prescriptions from 5 or more groups. The most commonly prescribed drug groups in the entire population were penicillins and β -lactam antimicrobials (17%; n=23,734), antidepressants (13%; n=18,028), opioid analgesics (12%; n=16,954), antilipemic agents (11%; n=16,082), and vaccines/toxoids (11%; n=15,918). However, prescribing patterns differed by age and sex. Vaccines/toxoids, penicillins and β -lactam antimicrobials, and antiasthmatic drugs were most commonly prescribed in persons younger than 19 years. Antidepressants and opioid analgesics were most commonly prescribed in young and middle-aged adults. Cardiovascular drugs were most commonly prescribed in older adults. Women received more prescriptions than men for several drug groups, in particular for antidepressants. For several drug groups, use increased with advancing age.

Conclusion: This study provides valuable baseline information for future studies of drug utilization and drug-related outcomes in this population.

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Prescription drug use has increased steadily in the United States for the past decade. The percentage of people who took at least 1 prescription drug in the past month increased from 44% in 1999-2000 to 48% in 2007-2008.¹ This increased use resulted in increased spending on prescription drugs, which reached \$250 billion in 2009, and accounted for 12% of total personal health care expenditures.² Drug-related spending is expected to continue to grow in the coming years.²

Quantification of drug-prescribing patterns in the general population is important for a variety of reasons. Prescription drug abuse has become the fastest-growing drug problem in the United States.^{3,4} Medication-related adverse outcomes in US hospitals and emergency departments increased 52% between 2004 and 2008.⁵ In addition, drug-prescribing patterns

may serve as indirect measures of the burden of diseases in a population.^{6,7} Prescribing patterns also vary considerably across geographic regions⁸⁻¹⁰ and may serve as a proxy for health system performance.

A variety of studies have described patterns of drug prescription in some countries, including Sweden, Spain, and Canada.¹¹⁻¹³ However, there are few population-based studies of prescription drugs in the United States because of the lack of a centralized health care data system.¹⁴ Some of the published US studies were conducted decades ago and may not reflect current prescription patterns.¹⁵⁻²⁴ More recent studies included only the Medicare-eligible elderly population or individuals with health insurance coverage.^{8,25} In this study, we examined the outpatient drug-prescribing patterns for the entire Olmsted County, Minnesota, population in 2009 using the Rochester Epidemiology Project (REP), a



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medical records linkage system that captures virtually all the health care visit information for the entire population.²⁶⁻²⁹

PATIENTS AND METHODS

Study Population

All individuals residing in Olmsted County between January 1 and December 31, 2009, were identified using the REP census (n=146,687),²⁶ and those who had given permission for their medical records to be used for research were included in this study (n=142,377; 97.1%). The number of people included in this study represented 98.7% of the population predicted to reside in Olmsted County by the US Census, and the age and sex distributions were virtually identical to those of the US Census estimates.²⁷ Additional details about the population of Olmsted County and about the REP have been published elsewhere.²⁶⁻²⁹

Drug Prescription Records

Outpatient drug prescriptions written for the study population between January 1 and December 31, 2009, were obtained from Mayo Clinic and the Olmsted Medical Center (both in Rochester, Minnesota) and were linked to specific individuals in the records linkage system (n=663,736 prescription records). As described elsewhere, these 2 institutions provide most of the medical care for Olmsted County residents.²⁶⁻²⁹ Since 2002, both institutions have used proprietary electronic prescription systems in their outpatient settings (ie, office and hospital outpatient settings). Electronic prescriptions in 2009 were retrieved from the proprietary systems and were converted into RxNorm codes retrospectively. The prescriptions were then grouped using the National Drug File—Reference Terminology (NDF-RT) classification system.^{30,31} Combination drugs with multiple ingredients were counted once under the NDF-RT category of the main ingredient or, if applicable, under the combination drug category.

Approximately 2% of the prescription records (n=12,576) were excluded because they lacked specific descriptions and could not be assigned to an NDF-RT class. All the remaining prescriptions were grouped into 28 NDF-RT classes. In this study, we focused on drug classes that were prescribed to at least 1% of the Olmsted County population; therefore, 8 NDF-RT

prescription classes were excluded (prescriptions were written to <1% of the population), leaving 20 classes for the analysis. The NDF-RT classification system also includes detailed subgroups for each class. Using the NDF-RT subgroups with some modifications (combining related or rarely prescribed subgroups), we classified all the prescriptions into 70 drug groups (Supplemental Table 1, available online at <http://www.mayoclinicproceedings.org>). All the drug groups were mutually exclusive. A person who received multiple prescriptions in the same drug group during the 12 months of the study was counted only once, and we did not consider refills or duration of drug use. Overall, 380,441 unique prescription records were included in the analyses.

Statistical Analyses

Prevalence was estimated by dividing the number of individuals who received drugs from each group during a 12-month period by the 2009 Olmsted County population (1-year prevalence). Age- and sex-specific prevalence patterns were explored graphically. Age-standardized or age- and sex-standardized prevalence figures were obtained by direct standardization to the entire US population (2000 US Census) when appropriate. Because the study covered the complete population of Olmsted County and no sampling was involved, statistical tests and CIs are not included in the tables.³²⁻³⁴

RESULTS

Overall Prevalence

The 2009 REP census population included 142,377 individuals. Approximately half of the population were men or boys (47%; n=66,865), 27% (n=38,558) were younger than 19 years, and 12% (n=17,336) were 65 years or older. Most of the population was white (92%; n=131,069). Overall, 68.1% of the population (n=96,953) received a prescription from at least 1 drug group, 51.6% (n=73,501) received prescriptions from 2 or more drug groups, and 21.2% (n=30,218) received prescriptions from 5 or more drug groups. A higher percentage of women or girls received at least 1 drug prescription compared with men or boys (72.5% [n=54,721/75,512] vs 63.2% [n=42,232/66,865]).

Overall, 17% (n=23,734) of the population received at least 1 prescription for penicillins and β -lactam antimicrobials, which was the most commonly prescribed drug group in the entire population. Antidepressants (13%; n=18,028), opioid analgesics (12%; n=16,954), antilipemic agents (11%; n=16,082), and vaccines/toxoids (11%; n=15,918) were next in decreasing order of frequency. The Table reports the 20 most commonly prescribed drug groups and the prescription prevalence by sex and age groups. The prevalence figures for 20 additional groups of prescription drugs in decreasing order of frequency are reported in Supplemental Table 2 (available online at <http://www.mayoclinicproceedings.org>).

Prevalence by Age and Sex

The prevalence of the most commonly prescribed drugs varied by age and sex (Figure 1). In general, women had a higher prescription prevalence for most drug groups except for cardiovascular disease drugs (including antilipemic agents, β -blockers and related medications, and angiotensin-converting enzyme inhibitors). The prevalence of most of the drug groups increased with advancing age. However, vaccine/toxoids, and penicillin and β -lactam antimicrobial prescriptions were most prevalent in children, decreased in young adults, and then slowly increased with age. Prescriptions for antidepressants, opioid analgesics, gastrointestinal medications, laxatives, and cardiovascular disease drugs increased sharply with age. In contrast, prescriptions for antiasthmatics, topical anti-infective/anti-inflammatory agents, erythromycins/macrolides, topical nasal and throat agents, and antihistamines had a relatively stable prevalence across all age groups.

The most commonly prescribed drug groups varied by age (Table and Figure 2). In children (<19 years old), the top prescriptions were vaccines/toxoids, penicillins and β -lactam antimicrobials, and antiasthmatic drugs. In contrast, the most common prescriptions in persons 65 years or older were antilipemic agents and β -blockers and related medications. Finally, prescribing patterns varied by sex within age groups. For example, in children (<19 years old), drug-prescribing patterns were similar between boys and girls. However, central nervous system stimulants were more commonly prescribed to boys than to girls (data not shown). In young adults

(19-29 years old), systemic contraceptives were the most common prescription, but were restricted to women. Similarly, antidepressants were the most common drug group in the 30- to 49-year-old population, with an overall prevalence of 17% (n=6310/37,927). Again, the prevalence of antidepressants was driven by a higher frequency of prescriptions to women in this age group (22%; n=4357/20,039).

DISCUSSION

Overall Findings

Outpatient prescriptions for drugs were highly prevalent in the Olmsted County population in this 2009 study. In a 12-month period, almost 70% of the population received a prescription from at least 1 drug group, more than 50% received prescriptions from 2 or more drug groups, and more than 20% received prescriptions from 5 or more drug groups. The most prevalent prescriptions were penicillins and β -lactam antimicrobials, antidepressants, opioid analgesics, and antilipemic agents. These drugs were prescribed to both sexes across all age groups (except for antilipemic agents, which were rarely used before age 30 years). However, prescribing patterns differed substantially across age and sex groups. Overall, women and older adults received more prescriptions.

In general, drug-prescribing patterns in this population are consistent with those in previous population-based studies in the United States.^{1,22} The prevalence of prescription drug use is high in the United States. The National Health and Nutrition Examination Survey (NHANES) reported a 48% monthly use of 1 or more prescription drugs in 2007-2008.¹ Another survey reported that 50% of US adults took at least 1 medication weekly.¹⁸ Our findings cannot be compared directly with findings from these previous studies because of differences in methods (weekly or monthly use vs annual use and data derived from drug prescriptions vs self-reports, pharmacy records, or insurance claims).³⁵

Antibiotics, vaccines, asthma medicines, and central nervous system stimulants were commonly prescribed to children, whereas oral contraceptives, antibiotics, antidepressants, and opioid analgesics were commonly prescribed to young and middle-aged adults. As expected, cardiovascular disease drugs were the most

TABLE. Age- and Sex-Specific Prevalence (per 100 Population) of the 20 Most Common Drug Groups in the 2009 Olmsted County, Minnesota, Population (n=142,377)^a

Drug group	Age (y) ^b										All ages		
	0-18		19-29		30-49		50-64		≥65		Crude ^c		Standardized % ^d
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Penicillins and β -lactam antimicrobials													
Both sexes	8771	22.75	3177	13.26	5563	14.67	3462	14.08	2761	15.93	23,734	16.67	16.60
Men/boys	4377	22.32	1035	10.01	2170	12.13	1433	12.47	1181	15.68	10,196	15.25	15.07
Women/girls	4394	23.19	2142	15.71	3393	16.93	2029	15.50	1580	16.12	13,538	17.93	18.13
Antidepressants													
Both sexes	1010	2.62	2663	11.11	6310	16.64	4900	19.93	3145	18.14	18,028	12.66	12.51
Men/boys	409	2.09	766	7.41	1953	10.92	1493	12.99	978	12.98	5599	8.37	8.56
Women/girls	601	3.17	1897	13.92	4357	21.74	3407	26.02	2167	22.11	12,429	16.46	16.21
Opioid analgesics													
Both sexes	1606	4.17	2898	12.09	5258	13.86	3844	15.63	3348	19.31	16,954	11.91	11.84
Men/boys	847	4.32	1064	10.29	2117	11.83	1706	14.84	1354	17.97	7088	10.60	10.77
Women/girls	759	4.01	1834	13.45	3141	15.67	2138	16.33	1994	20.34	9866	13.07	12.85
Antilipemic agents													
Both sexes	15	0.04	127	0.53	2539	6.69	6377	25.94	7024	40.52	16,082	11.30	11.07
Men/boys	10	0.05	77	0.74	1635	9.14	3386	29.45	3292	43.70	8400	12.56	12.73
Women/girls	5	0.03	50	0.37	904	4.51	2991	22.85	3732	38.07	7682	10.17	9.57
Vaccines/toxoids													
Both sexes	8926	23.15	1878	7.84	2259	5.96	1742	7.08	1113	6.42	15,918	11.18	11.07
Men/boys	4330	22.08	550	5.32	1048	5.86	798	6.94	481	6.39	7207	10.78	10.40
Women/girls	4596	24.26	1328	9.74	1211	6.04	944	7.21	632	6.45	8711	11.54	11.77
Antiasthmatics													
Both sexes	3921	10.17	1697	7.08	3520	9.28	2477	10.07	2080	12.00	13,695	9.62	9.56
Men/boys	2138	10.90	538	5.20	1208	6.75	827	7.19	819	10.87	5530	8.27	8.22
Women/girls	1783	9.41	1159	8.50	2312	11.54	1650	12.60	1261	12.86	8165	10.81	10.83
Topical anti-infective/anti-inflammatory agents													
Both sexes	2952	7.66	1529	6.38	3122	8.23	2840	11.55	2819	16.26	13,262	9.31	9.22
Men/boys	1467	7.48	503	4.87	1144	6.40	1130	9.83	1229	16.31	5473	8.19	8.20
Women/girls	1485	7.84	1026	7.53	1978	9.87	1710	13.06	1590	16.22	7789	10.31	10.23
Erythromycins/macrolides													
Both sexes	3364	8.72	1843	7.69	3963	10.45	2385	9.70	1507	8.69	13,062	9.17	9.13
Men/boys	1653	8.43	513	4.96	1360	7.60	906	7.88	598	7.94	5030	7.52	7.51
Women/girls	1711	9.03	1330	9.76	2603	12.99	1479	11.30	909	9.27	8032	10.64	10.71
Gastrointestinal medications, other													
Both sexes	395	1.02	998	4.16	3074	8.11	3321	13.51	3253	18.76	11,041	7.75	7.70
Men/boys	184	0.94	373	3.61	1319	7.37	1370	11.92	1276	16.94	4522	6.76	6.92
Women/girls	211	1.11	625	4.59	1755	8.76	1951	14.90	1977	20.17	6519	8.63	8.39
Laxatives													
Both sexes	675	1.75	727	3.03	2352	6.20	3858	15.69	2705	15.60	10,317	7.25	7.05
Men/boys	303	1.55	199	1.93	863	4.82	1761	15.32	1235	16.39	4361	6.52	6.50
Women/girls	372	1.96	528	3.87	1489	7.43	2097	16.02	1470	15.00	5956	7.89	7.63
β -Blockers and related medications													
Both sexes	77	0.20	235	0.98	1357	3.58	3201	13.02	5229	30.16	10,099	7.09	6.97
Men/boys	34	0.17	76	0.74	633	3.54	1717	14.94	2420	32.13	4880	7.30	7.45
Women/girls	43	0.23	159	1.17	724	3.61	1484	11.34	2809	28.65	5219	6.91	6.59
ACE inhibitors													
Both sexes	30	0.08	112	0.47	1455	3.84	3418	13.90	4740	27.34	9755	6.85	6.75
Men/boys	19	0.10	75	0.73	879	4.91	1920	16.70	2190	29.07	5083	7.60	7.73
Women/girls	11	0.06	37	0.27	576	2.87	1498	11.44	2550	26.01	4672	6.19	5.87

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TABLE. *Continued*

Drug group	Age (y) ^b										All ages		
	0-18		19-29		30-49		50-64		≥65		Crude ^c		Standardized % ^d
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Diuretics													
Both sexes	46	0.12	147	0.61	1368	3.61	3100	12.61	5092	29.37	9753	6.85	6.75
Men/boys	21	0.11	54	0.52	550	3.07	1313	11.42	1969	26.14	3907	5.84	5.99
Women/girls	25	0.13	93	0.68	818	4.08	1787	13.65	3123	31.86	5846	7.74	7.37
Topical nasal and throat agents													
Both sexes	1419	3.68	1088	4.54	2766	7.29	2202	8.96	1635	9.43	9110	6.40	6.37
Men/boys	822	4.19	381	3.69	1090	6.09	909	7.91	702	9.32	3904	5.84	5.88
Women/girls	597	3.15	707	5.19	1676	8.36	1293	9.88	933	9.52	5206	6.89	6.84
Antihistamines													
Both sexes	2013	5.22	1330	5.55	2655	7.00	1919	7.80	1117	6.44	9034	6.35	6.28
Men/boys	1092	5.57	395	3.82	876	4.90	614	5.34	404	5.36	3381	5.06	5.04
Women/girls	921	4.86	935	6.86	1779	8.88	1305	9.97	713	7.27	5653	7.49	7.45
Antirheumatics													
Both sexes	989	2.56	1325	5.53	2798	7.38	2108	8.57	1153	6.65	8373	5.88	5.83
Men/boys	466	2.38	430	4.16	1113	6.22	898	7.81	469	6.23	3376	5.05	5.10
Women/girls	523	2.76	895	6.57	1685	8.41	1210	9.24	684	6.98	4997	6.62	6.54
Sedatives/hypnotics													
Both sexes	205	0.53	969	4.04	2816	7.42	2282	9.28	1635	9.43	7907	5.55	5.53
Men/boys	93	0.47	308	2.98	1059	5.92	885	7.70	611	8.11	2956	4.42	4.54
Women/girls	112	0.59	661	4.85	1757	8.77	1397	10.67	1024	10.45	4951	6.56	6.45
Adrenal corticosteroids													
Both sexes	1498	3.89	799	3.33	1982	5.23	1559	6.34	1549	8.94	7387	5.19	5.17
Men/boys	862	4.40	302	2.92	726	4.06	587	5.11	657	8.72	3134	4.69	4.71
Women/girls	636	3.36	497	3.65	1256	6.27	972	7.42	892	9.10	4253	5.63	5.61
Quinolones													
Both sexes	191	0.50	969	4.04	2009	5.30	1899	7.72	2272	13.11	7340	5.16	5.08
Men/boys	63	0.32	237	2.29	662	3.70	736	6.40	863	11.46	2561	3.83	3.94
Women/girls	128	0.68	732	5.37	1347	6.72	1163	8.88	1409	14.37	4779	6.33	6.15
Systemic contraceptives													
Both sexes ^e	...	...	...	...	...	...	...	...	...	...	...	...	...
Men/boys ^e	...	...	...	...	...	...	...	...	...	...	...	...	...
Women/girls	880	4.64	3352	24.59	2575	12.85	170	1.30	18	0.18	6995	9.26	9.10

^aACE = angiotensin-converting enzyme.

^bNumbers indicate the actual number of cases observed. Prevalence can be computed by dividing the number of cases by the corresponding denominator listed next (and multiplying by 100). Denominators for men/boys and women/girls combined: 0-18 y, 38,558; 19-29 y, 23,968; 30-49 y, 37,927; 50-64 y, 24,588; and ≥65 y, 17,336. Denominators for men/boys: 0-18 y, 19,611; 19-29 y, 10,337; 30-49 y, 17,888; 50-64 y, 11,496; and ≥65 y, 7533. Denominators for women/girls: 0-18 y, 18,947; 19-29 y, 13,631; 30-49 y, 20,039; 50-64 y, 13,092; and ≥65 y, 9803.

^cA crude prevalence was computed by dividing cases observed across all ages by the total population.

^dOverall prevalence for men/boys and women/girls combined was standardized by age and sex; overall prevalence for men/boys and women/girls separately was standardized only by age (direct standardization using the 2000 US Census population).

^eA total of 49 prescriptions for systemic contraceptives (0.7% [n=49/7044]) were assigned to men/boys by mistake.

commonly prescribed drugs in older adults, with 41% of individuals 65 years or older receiving an antilipemic prescription. Men had a higher prevalence of cardiovascular disease drug prescriptions than women, which was consistent with cardiovascular disease patterns. Specifically, the incidence of cardiovascular disease in women lags 10 years behind the incidence in men,³⁶ and a similar pattern

was reflected in the present drug prescription data. However, when considering all prescription drugs, women received more prescriptions than men. This may be caused by the higher frequency of diseases or conditions requiring medication in women or by differences in health care-seeking behavior between men and women.³⁷ For example, among patients with migraines, 73% of

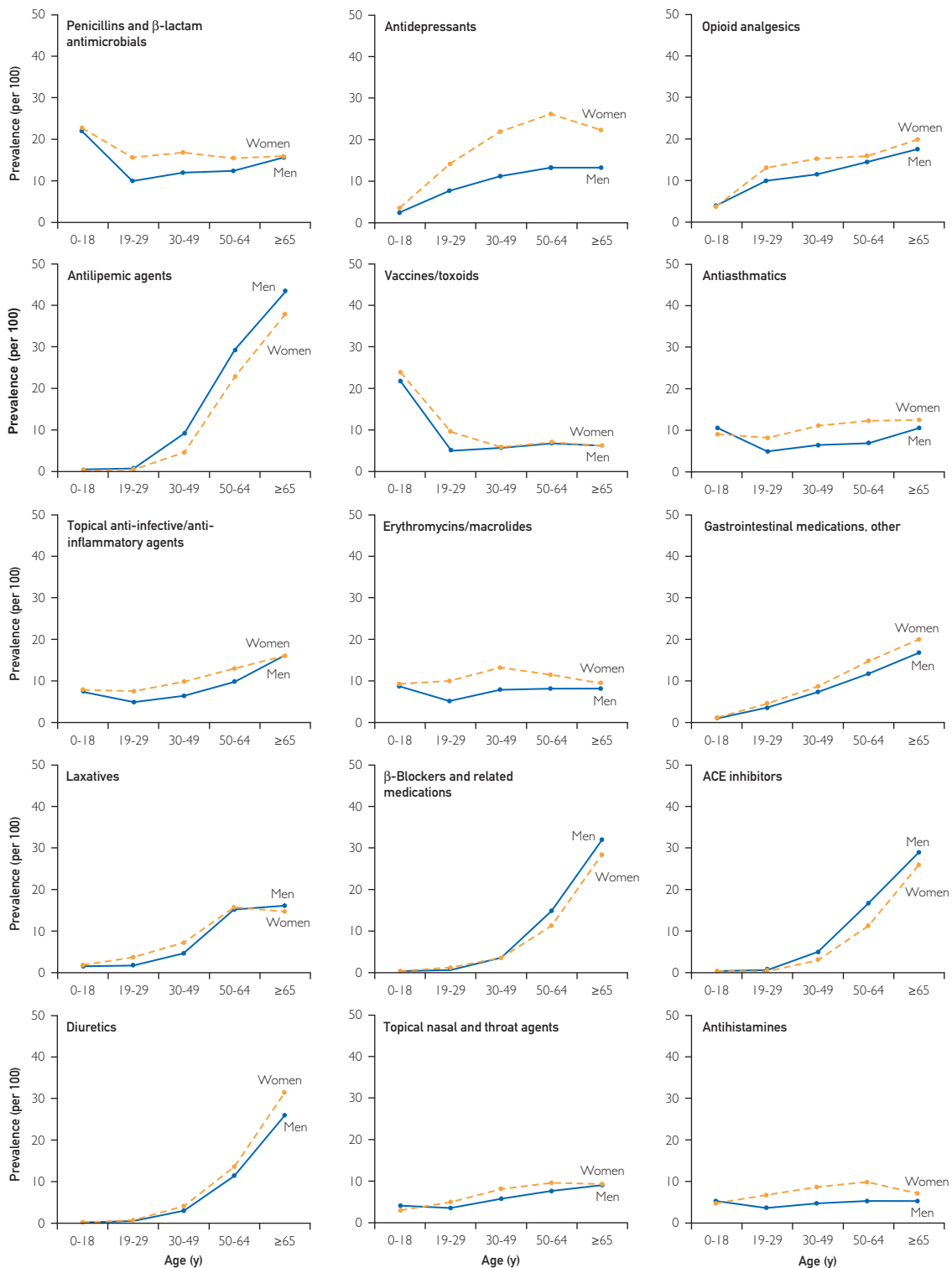


FIGURE 1. Age-specific prevalence (per 100 population) of the 15 most commonly prescribed drug groups in men/boys compared with women/girls. The 15 panels are in descending order of overall age- and sex-adjusted prevalence (Table). ACE = angiotensin-converting enzyme.

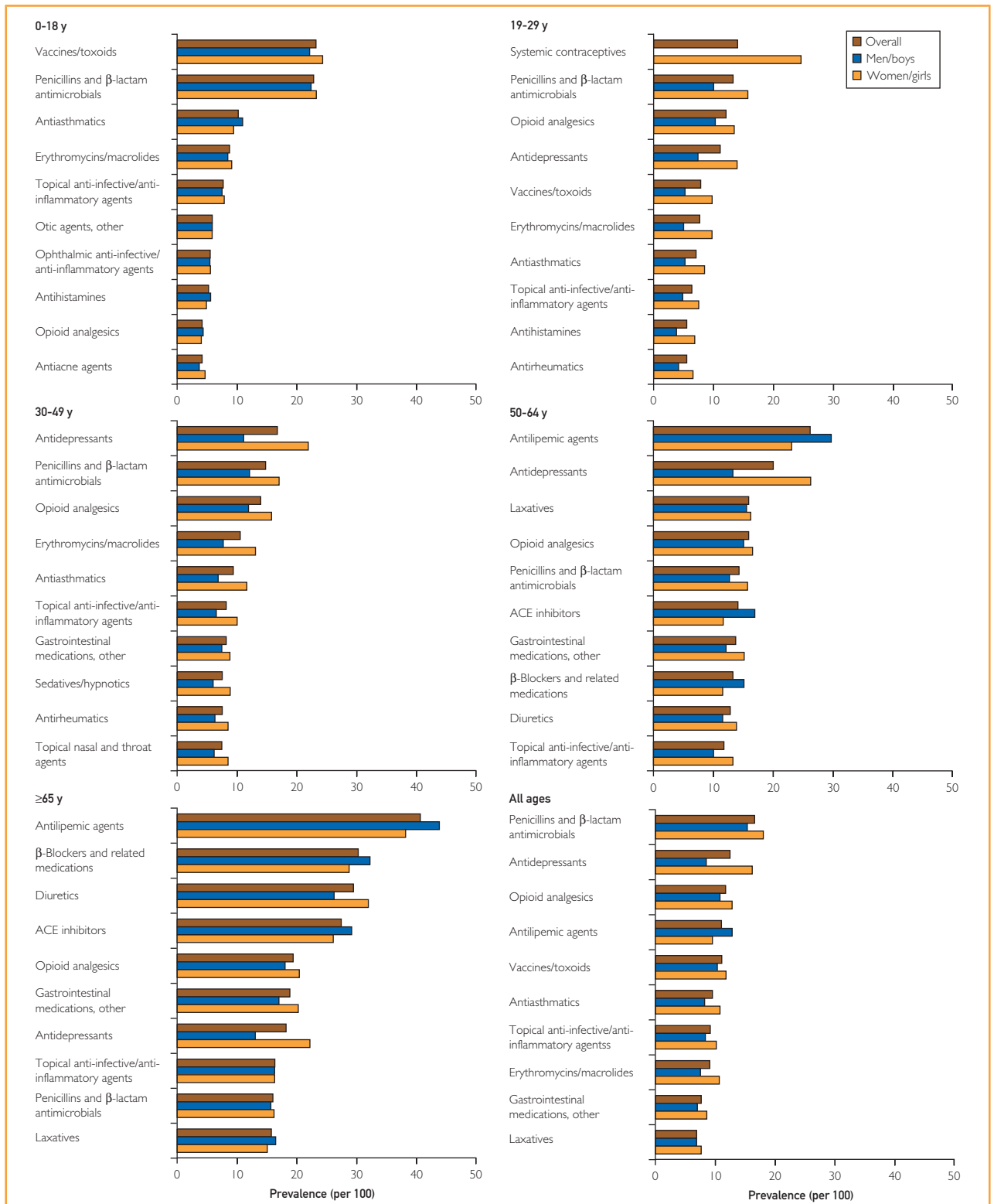


FIGURE 2. Prevalence (per 100 population) of the 10 most commonly prescribed drug groups in each age category overall and by sex. ACE = angiotensin-converting enzyme.

women seek care from physicians compared with 49% of men.³⁸

Specific Drug Groups

This study provides an overview of prescription patterns in this community and highlights some of the commonly used drug groups that deserve further research, as described in the following paragraphs. Penicillins and β -lactam antimicrobials are the most commonly prescribed drugs, especially in children. The high prevalence of prescriptions for penicillins and β -lactam antimicrobials (approximately 25% of all children in 2009) reflects the high rate of bacterial infections (such as ear and throat infections). Appropriate use of antibiotics is a major public health concern,³⁹ and we plan to further study antibiotic prescriptions through linkage with laboratory and medical record data to explore prescribing appropriateness, type and duration of use, and use of multiple antibiotics.

Antidepressants are the second most prescribed drug group (13%), particularly in middle-aged women. This sex difference has been reported in other studies.^{22,40,41} The increased prescription of antidepressants in recent years has occurred concurrently with a decreasing use of psychotherapy.⁴² However, many antidepressants are not prescribed by psychiatrists⁴³ and are prescribed to patients who may not have a psychiatric diagnosis.⁴⁴ Further studies considering indications may be helpful to understand the use of antidepressant drugs for conditions other than depression.

Opioid analgesics are the third most common prescription group in this population. In the United States, there has been a 10-fold increase in the medical use of opioid painkillers during the past 20 years.⁴⁵ Concerns regarding opioid misuse are increasing in the United States because deaths from opioid overdose currently outnumber deaths due to heroin and cocaine use combined.⁴⁵ The 12-month prevalence of opioid prescriptions (12%) in the present study was consistent with that in previous reports.^{1,45} Also, consistent with other studies, women had a higher prevalence of opioid prescriptions than men.^{1,21,40,45} This finding is likely due to a higher prevalence of diseases associated with chronic pain in women⁴⁶ but also to a lower pain tolerance and a higher subjective pain rating in women than in men.^{47,48} Osteoarthritis

and joint disorders and back problems are the second and third most common chronic conditions in this community.⁴⁹ Therefore, it is not surprising that the use of opioid analgesics was common. However, it is surprising that opioid analgesics were prescribed in all age groups, including young adults, who generally do not have chronic pain conditions. This pattern can be explained by the inclusion of opioid analgesics prescribed for both acute and chronic pain. Opioid analgesics are often prescribed to manage acute pain after surgical procedures or trauma, and patients are instructed to use the analgesic only if needed. In addition, we included prescriptions given to patients at the time of dismissal from the hospital or emergency department (eg, hydrocodone/acetaminophen and oxycodone). These types of short-term prescriptions may be common in the younger population after dental procedures. Nevertheless, the high level of opioid prescriptions among all the individuals in this population suggests the importance of future studies to determine whether alternative pain management agents should be considered.

In this study, antilipemic agents were the fourth most commonly prescribed drug group overall, and the high use was driven primarily by prescriptions to persons 50 years or older. In persons 65 years or older, 41% received at least 1 antilipemic prescription in 2009. This finding is similar to the monthly percentage estimated from the NHANES in 2007-2008 (45% of adults aged ≥ 60 years).¹ The NHANES data also estimated that 33.5% of US adults older than 20 years have increased low-density lipoprotein (LDL) cholesterol levels, and this prevalence increases to 58% in adults 65 years or older.⁵⁰ However, less than half of those with high LDL cholesterol levels were treated, and even fewer had the LDL cholesterol level controlled.⁵⁰ Applying similar estimates to the present population, we expect that antilipemic agents may be underprescribed in a large percentage of patients. We plan to address antilipemic agent use patterns in future studies. These studies will also incorporate serial lipid blood test results and other detailed information from medical records.

Strengths and Limitations

The strengths of this study include the availability of complete medical visit information for

the entire Olmsted County population. For a combination of geographic and historical circumstances, almost all the county residents seek health care from a limited number of local providers. Furthermore, all residents, irrespective of insurance status, are included in both the denominator and the numerator of the prevalence figures, providing a more complete picture of prescribing patterns in the community.

Some utilization studies rely on self-reported drug use, which may more accurately reflect actual drug exposure; however, recall bias is a problem for past use.^{2,18} In particular, interviewees tend to underreport their medication use.⁵¹ In addition, self-reported drug use does not necessarily reflect prescribing patterns by the health care providers because not all prescriptions are filled.²⁵ However, utilization estimates derived from pharmacy records, claims, and other administrative databases may have a higher sensitivity for actual drug exposure.

A potential limitation of prescription-based studies, such as this one, is the inability to determine whether the patients actually purchased and used the drugs (adherence with the prescription). Therefore, the patterns of prescriptions that we observed may not reflect the patterns of actual drug use in the population. Nevertheless, the ability to link prescription data with diagnoses and with clinical details in the electronic medical records is a unique strength of the REP and will form the basis for future utilization and outcome studies focused on individual drugs or drug groups.

A second limitation of this database is that many commonly used drugs are not prescription drugs and can be purchased over-the-counter (such as cold medicines); therefore, they are not found among the most commonly prescribed drugs. This also applies to vaccines that are more completely captured in vaccine registries. A third limitation is our inability to include drug prescriptions from a few smaller health care practices in Olmsted County that do not have an electronic drug prescription system.^{26,29} Thus, we may have underestimated the frequency of use for some drug groups.

Fourth, drug formularies, prescribing guidelines, and decision support systems may vary substantially across health care practices throughout the country. Therefore, the prescribing patterns that we observed in Olmsted

County may not be generalizable to other regions. On the other hand, drug formularies, prescribing guidelines, and decision support systems may influence more strongly the choice of a drug within a particular drug group than the choice of the drug group itself. Thus, the patterns of drug groups may be more generalizable to other populations than the patterns of specific drugs.

Finally, we considered the use of drugs in a 12-month period to avoid seasonal variations in prescriptions for some drugs (eg, allergy drugs). However, the 12-month prevalence used in this study does not distinguish between long-term use (repeated prescriptions) and onetime use of drugs (eg, antibiotics), and does not reflect multiple prescriptions in the same drug group (switches) or the frequency of drug prescribing in an individual patient. We also have not assessed refills and instructions for use, such as directions to use the drug only if needed (eg, for opioid analgesics). Duration of drug use may be particularly important when investigating issues such as chronic disease management, drug abuse, and outcomes. We are currently performing additional analyses to address issues of indications, duration of use, and per capita prescriptions in each drug group to provide a more complete picture of drug utilization in this community.

CONCLUSION

A high percentage of the overall Olmsted County population received outpatient prescription drugs in 2009. The drug-prescribing patterns varied substantially by age and sex. In general, women and older individuals received more prescriptions. These findings are useful for understanding the prescribing patterns across all ages in a defined population and provide important baseline information for future studies of drug-related adverse events, drug-to-drug interactions, polypharmacy, health-seeking behaviors, and other prescription-related aspects of health care utilization.

ACKNOWLEDGMENTS

We thank Carol Greenlee for formatting the submitted manuscript. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Aging.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at <http://www.mayoclinicproceedings.org>.

Abbreviations and Acronyms: LDL = low-density lipoprotein; NDF-RT = National Drug File—Reference Terminology; NHANES = National Health and Nutrition Examination Survey; REP = Rochester Epidemiology Project

Grant Support: This study was made possible by the Rochester Epidemiology Project (grant number R01AG034676; Principal Investigators: Walter A. Rocca, MD, MPH, and Barbara P. Yawn, MD, MSc). Additionally, this publication was supported by the Mayo Clinic Center for the Science of Healthcare Delivery.

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