Characteristics and drug utilization patterns for heavy users of prescription drugs among the elderly: a Danish register-based drug utilization study

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Abstract

Purpose The objectives of this study were to (1) identify and characterize heavy users of prescription drugs among persons aged 60 years and above; (2) investigate the association of demographic, socioeconomic, and health-related variables with being a heavy drug user; and (3) study the most frequently used drugs among heavy drug users and development in use over time.

Method This is a descriptive study. Heavy drug users were defined as the accumulated top 1 percentile who accounted for the largest share of prescription drug use measured in number of dispensed defined daily doses (DDDs). The nationwide Danish registers were used to obtain data. Multivariable logistic binary regression was used to determine which factors were associated with being a heavy drug user.

Results Heavy drug users among persons aged 60 years and above accounted for 6.8, 6.0, and 5.5 % of prescription drug use in 2002, 2007, and 2012, respectively. Male gender, those aged 60–69 years, being divorced, shorter education, low annual income, and recent hospitalization were all significantly associated with being in the top 1 percentile group of drug users ($p < 0.05$). The ten most frequently used drug classes among heavy drug users accounted for 75.4 % of their use in 2012, and five of these were cardiovascular drugs. The development over time for the ten most used drug classes followed the same pattern among heavy drug users and in the general population.

Conclusion There is a skewed utilization of prescription drugs. Contrary to earlier findings, being male was associated with heavy prescription drug use both with respect to number of drugs used and drug expenditure.

Introduction

Drug utilization studies have previously shown that women use more drugs than men and that the use of drugs increases with age [1–7]. Apart from gender and age, other factors have shown correlation with the use of prescription drugs, such as education [2–4], employment [7, 8], income [3, 7], visits to the GP [2, 6], and living in institutions [9].

A relatively small group of people account for a large share of the prescription drug use, and this seems to be particularly evident for certain drug classes [2, 8, 10–13]. By identifying this group of heavy drug users and comparing their characteristics and drug utilization patterns to that of the general population, factors associated with heavy use may be uncovered. It can be expected that persons in such a group are subject to polypharmacy and that they account for a relatively large share of total pharmaceutical costs in the society [10–12]. Individuals who use several drugs are at increased risk of experiencing medication errors [14], which can lead to the

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occurrence of adverse drug events reported to cause about 6 % of all admissions to hospitals [15].

There are no previous nationwide studies focusing on heavy drug users in any age groups in Denmark. Hence, this study aimed to identify and characterize heavy users of prescription drugs in Denmark among adults aged 60 years and above and further to study which drugs they used most frequently. Specifically, we looked at (1) demographic, socioeconomic, and health characteristics for heavy drug users in the years 2002, 2007, and 2012 and compared them to the general population in the respective age group; (2) to what extent certain demographic and socioeconomic factors were associated with being a heavy drug user; and (3) drug utilization patterns and costs in 2012 for the ten most used drug classes and drug compounds and development in drug use over time for the ten most used drug classes from 2002 to 2012 for heavy drug users compared to the general population. This is the first study to focus on the group of heavy drug users definded as the top 1 percentile in a population.

Material and methods

This study is a quantitative description of the use of prescription drugs for heavy drug users in Denmark among people aged 60 years and above. We obtained prescription data as well as socio-demographic and health-related data for the 3 years studied: 2002, 2007, and 2012. The year 2012 was the most recent year for which we could obtain data, and we wished to examine whether the characteristics of the heavy drug users were different to those 5 and 10 years earlier. Throughout this study, the main focus is on the heavy drug users, and comparisons are always to the Danish population aged 60 years and above.

Data sources

The nationwide Danish registers contain valuable information related to health and social issues. They cover the entire Danish population for long periods of time offering great possibilities for register-based epidemiological research [16].

The Danish Civil Registration System [17] was used to extract the demographic variables age, gender, residency, and marital status.

The Student Register [18] was used to determine the length of education and the Income Statistics Register [19] to obtain data on income.

The Danish National Prescription Registry [20] contains information about variables related to the drug user and the drug purchased. The data extracted were the date of dispensing, pharmacy retail price, patient co-payment, reimbursement codes, Anatomical Therapeutic Chemical (ATC) classification code, and the number of defined daily doses (DDDs) dispensed [21].

From the Danish National Patient Register [22], the patient's date and time of admission, and discharge from the hospital were extracted.

The Central Person Register (CPR) number provides the opportunity of linking anonymous data on citizens between all national registers in Denmark by Statistics Denmark [23].

According to Danish law, the study did not require ethics board approval [16] and was approved by the Danish Data Protection Agency.

Analysis

The analyses were intended to describe the characteristics of heavy drug users and their utilization of prescription drugs. The *general Danish population* used for comparison was the remaining number of persons in the respective age groups, and the term *total population* is used for all persons aged 60 years and above (i.e., the heavy drug users and the general population combined).

All persons had to (1) be aged 60 years or older, (2) had been alive and not emigrated during the whole year studied, and (3) had been living 5 or more years in Denmark.

The group of heavy drug users was the accumulated top 1 percentile of the population who accounted for the largest share of prescription drug dispensed at pharmacies measured in number of DDDs during the respective calendar years of 2002, 2007, and 2012. Only redeemed prescriptions containing valid data on number of DDDs were included (95.3 %). We extracted data on demographic, socioeconomic, and health variables and compared the distribution of the heavy drug users across these variables to that of the general population in the same year.

We used multivariable logistic binary regression to explore the association of various variables with being a heavy drug user or not in 2012. Based on the literature, the following variables were included in the model: (1) gender, male and female; (2) age, 60–69, 70–79, 80–89, and ≥90 years; (3) civil status, married, single, widowed, and divorced; (4) residency, North Denmark, Mid Denmark, South Denmark, Zealand, and capital; (5) education, short (7–10 years), medium (11–13 years), and long (≥14 years); (6) income, 0–199,000 DKK, 200,000–399,999 DKK, and 400,000+ DKK; and (7) whether a person had been hospitalized during the previous year or not. The results of multivariable logistic analysis are reported showing odds ratios (ORs) and a 95 % confidence interval.

The ten most used drug classes and drug compounds among heavy drug users in 2012 were compared with those of the general population. A drug class was defined as the second level in the ATC classification system (i.e., the therapeutic subgroup). A drug compound was defined as the fifth

Table 1 Demographic, socioeconomic, and health characteristics of heavy drug users, compared to the general population in Denmark for the years 2002, 2007, and 2012

	2002			2007			2012		
	Heavy drug users (n)	General population (n)	Proportion ratio[a]	Heavy drug users (n)	General population (n)	Proportion ratio	Heavy drug users (n)	General population (n)	Proportion ratio
All	10,122	1,002,153		11,406	1,129,200		11,930	1,181,145	
Gender									
Female	5944 (58.7 %)	563,576 (56.2 %)	1.04	6196 (54.3 %)	619,268 (54.8 %)	0.99	6029 (50.5 %)	640,476 (54.2 %)	0.93
Male	4178 (41.3 %)	438,577 (43.8 %)	0.94	5210 (45.7 %)	509,932 (45.2 %)	1.01	5901 (49.5 %)	540,669 (45.8 %)	1.08
Age									
60–69	3959 (39.1 %)	480,846 (48.0 %)	0.82	5009 (43.9 %)	596,805 (52.9 %)	0.83	5241 (43.9 %)	600,987 (50.9 %)	0.86
70–79	3948 (39.0 %)	333,693 (33.3 %)	1.17	4192 (36.8 %)	336,429 (29.8 %)	1.23	4517 (37.9 %)	377,397 (32.0 %)	1.18
80–89	1972 (19.5 %)	162,779 (16.2 %)	1.20	1986 (17.4 %)	168,428 (14.9 %)	1.17	1924 (16.1 %)	171,328 (14.5 %)	1.11
≥90	243 (2.4 %)	24,835 (2.5 %)	0.97	219 (1.9 %)	27,538 (2.4 %)	0.79	248 (2.1 %)	31,433 (2.7 %)	0.78
Civil status									
Married	4596 (45.4 %)	564,031 (56.3 %)	0.81	5503 (48.2 %)	664,414 (58.8 %)	0.82	6018 (50.4 %)	704,281 (59.6 %)	0.85
Single	573 (5.7 %)	58,376 (5.8 %)	0.97	648 (5.7 %)	64,577 (5.7 %)	0.99	798 (6.7 %)	72,292 (6.1 %)	1.09
Widowed	3441 (34.0 %)	276,481 (27.6 %)	1.23	3279 (28.7 %)	265,662 (23.5 %)	1.22	2936 (24.6 %)	252,474 (21.4 %)	1.15
Divorced	1512 (14.9 %)	103,265 (10.3 %)	1.45	1976 (17.3 %)	134,547 (11.9 %)	1.45	2178 (18.3 %)	152,098 (12.9 %)	1.42
Residency[b]									
North Denmark	1372 (13.6 %)	105,895 (10.6 %)	1.28	1622 (14.2 %)	120,891 (10.7 %)	1.33	1627 (13.6 %)	125,827 (10.7 %)	1.28
Mid Denmark	2151 (21.3 %)	194,767 (19.4 %)	1.09	2459 (21.6 %)	230,058 (20.4 %)	1.06	2760 (23.1 %)	245,424 (20.8 %)	1.11
South Denmark	2649 (26.2 %)	251,293 (25.1 %)	1.04	2916 (25.6 %)	272,439 (24.1 %)	1.06	2900 (24.3 %)	285,457 (24.2 %)	1.01
Zealand	1510 (14.9 %)	155,729 (15.5 %)	0.96	1658 (14.5 %)	182,294 (16.1 %)	0.90	1767 (14.8 %)	193,690 (16.4 %)	0.90
Capital	2440 (24.1 %)	294,270 (29.4 %)	0.82	2751 (24.1 %)	322,362 (28.5 %)	0.84	2876 (24.1 %)	328,941 (27.8 %)	0.87
Highest achieved education[c]									
Short (7–10 years)	5280 (52.2 %)	418,692 (41.8 %)	1.25	6155 (54.0 %)	449,464 (39.8 %)	1.36	6090 (51.0 %)	422,326 (35.8 %)	1.43
Medium (11–13 years)	623 (6.2 %)	77,039 (7.7 %)	0.80	886 (7.8 %)	109,619 (9.7 %)	0.80	1123 (9.4 %)	135,056 (11.4 %)	0.82
Long (≥14 years)	2233 (22.1 %)	336,299 (33.6 %)	0.66	3451 (30.3 %)	481,859 (42.7 %)	0.71	4259 (35.7 %)	583,142 (49.4 %)	0.72
Annual income (DKR)[d]									
0–199,999	9097 (89.9 %)	770,486 (76.9 %)	1.17	9626 (84.4 %)	760,609 (67.4 %)	1.25	9427 (79.0 %)	712,465 (60.3 %)	1.31
200,000–399,999	893 (8.8 %)	189,072 (18.9 %)	0.47	1521 (13.3 %)	290,784 (25.8 %)	0.52	2109 (17.7 %)	350,868 (29.7 %)	0.60
400,000+	132 (1.3 %)	42,544 (4.2 %)	0.31	259 (2.3 %)	76,913 (6.8 %)	0.33	394 (3.3 %)	116,248 (9.8 %)	0.34
Hospitalized									
No	4600 (45.4 %)	819,128 (81.7 %)	0.56	5304 (46.5 %)	928,665 (82.2 %)	0.57	5727 (48.0 %)	966,323 (81.8 %)	0.59

Table 1 (continued)

	2002			2007			2012		
	Heavy drug users (n)	General population (n)	Proportion ratio[a]	Heavy drug users (n)	General population (n)	Proportion ratio	Heavy drug users (n)	General population (n)	Proportion ratio
Yes	5522 (54.6 %)	183,025 (18.3 %)	2.99	6102 (53.5 %)	200,535 (17.8 %)	3.01	6203 (52.0 %)	214,822 (18.2 %)	2.86
Prescription drug use									
Mean number of drugs (IQR)	18 (14–22)	4 (2–8)		19 (15–23)	5 (2–8)		19 (15–23)	5 (2–9)	

All persons included are born in 1942, 1947, or 1952 or earlier, respectively

IQR interquartile range

[a] Ratio between proportion among heavy drug users and proportion in the general Danish population

[b] Missing values for up to 0.2 %

[c] Missing values for up to 19.6 %

[d] Missing values for up to 0.1 %

level in the ATC classification system (i.e., the chemical substance). The total number of users among the heavy drug users was used to determine which drug classes and drug compounds were in the top ten. A person was considered a user if he or she had purchased the drug compound or a drug within the drug class in question during 2012. We estimated the prevalence proportion ratio (PPR), which is the proportion of users among heavy drug users divided by the proportion of users in the general population. In Denmark, prescription drugs that have been approved for reimbursement are covered by the public health insurance [24], and we therefore looked at both public drug expenditure and the total expenditure and calculated the share of total drug expenditure and public drug expenditure accounted for by heavy drug users.

Development over the years studied in yearly prescription drug use for the ten most frequently used drug classes was studied as the number of DDDs per person per year for all ten drug classes in each consecutive year between 2000 and 2012 for both heavy drug users and the corresponding general population.

All analyses were performed using the statistical software package STATA version 13.0 (StataCorp College Station, TX).

Results

Heavy drug users (i.e., the top 1 percentile) among persons aged 60 years and above based on number of DDDs dispensed from pharmacies amounted to 10,122 persons in 2002, 11,406 in 2007, and 11,930 in 2012. Individuals who were removed from the population due to death/migration in year 2002 were 55,656 (5.21 %), 56,869 (4.75 %) in 2007, and 59,766 (4.77 %) in 2012. In 2012, top 1 percentile accounted for 5.5 % (81,096,356 of 1,488,410,323 DDDs) of the total number of DDDs dispensed to persons at the age of 60 years or above in Denmark. This was a 32.1 % increase from 2002 (61, 389,740 DDDs) and a 7.7 % increase from 2007 (75,276,158 DDDs). However, their share of the total number of DDDs dispensed to persons aged 60 years or above decreased over time going from 6.8 % in 2002 to 6.0 % in 2007 to 5.5 % in 2012.

Demographic, socioeconomic, and health characteristics for heavy drug users and the general population for the years 2002, 2007, and 2012 are shown in Table 1. The majority of heavy drug users for each year were female, but the gender differences decreased over the 3 years studied (58.7 % in 2002, 54.3 % in 2007, and 50.5 % in 2012). The distribution between the five regions in Denmark was skewed. The largest differences were found in North Denmark where heavy drug users were over-represented (PP 1.28 in 2002, PP 1.33 in 2007, and PP 1.28 in 2012) and in the capital where they were under-represented (PP 0.82 in 2002, PP 0.84 in 2007, and PP

0.87 in 2012). The majority of heavy drug users had short education (52.2 % in 2002, 54.0 % in 2007, and 51.0 % in 2012) and low income (89.9 % in 2002, 84.4 % in 2007, and 79.0 % in 2012).

The mean number of drugs among heavy drug users was 18 (interquartile range (IQR) 14–22) in 2002, 19 (IQR 15–23) in 2007, and 19 (IQR 15–23) in 2012, which was about four times that of the general population. The proportion of persons who had been admitted to a hospital was approximately three times higher for heavy drug users compared to the general population.

Factors associated with being a heavy user of prescription drugs in 2012 in the multivariable logistic binary regression are shown in Table 2. Male gender, younger age, being

Table 2 Factors associated with heavy use of prescription drugs among persons aged 60 years and above in Denmark using multiple logistic regression

Variables	OR	95 % CI
Gender		
Female[a]	1.00	
Male	1.39	(1.34–1.45)
Age		
60–69[a]	1.00	
70–79	0.97	(0.93–1.02)
80–89	0.73	(0.69–0.77)
≥90	0.52	(0.42–0.65)
Civil status		
Married[a]	1.00	
Single	1.21	(1.12–1.31)
Widowed	1.35	(1.28–1.42)
Divorced	1.56	(1.48–1.64)
Residency		
North Denmark	1.37	(1.29–1.46)
Mid Denmark	1.25	(1.18–1.32)
South Denmark	1.09	(1.04–1.16)
Zealand	0.99	(0.93–1.05)
Capital area[a]	1.00	
Highest achieved education		
Short (7–10 years)[a]	1.00	
Medium (11–12 years)	0.71	(0.67–0.76)
Long (≥13 years)	0.67	(0.64–0.69)
Annual income (DKK)		
0–199,999[a]	1.00	
200,000–399,999	0.53	(0.50–0.55)
400,000+	0.32	(0.29–0.36)
Hospitalized		
No	1.00	
Yes	4.64	(4.47–4.81)

OR odds ratio, CI confidence interval

[a] Indicates reference group

divorced, having a shorter education, low annual income, and recent hospitalization were associated with increased odds ratio of being a heavy drug user. Regarding residency, the highest odds ratio was found when living in North Denmark.

The ten most frequently used drug classes and drug compounds among heavy drug users in 2012 are shown in Table 3. These compounds accounted for 75.4 % of the total number of dispensed DDDs to heavy drug users. This was similar for 2007 (74.7 %) and 2002 (76.4 %).

Figure 1 shows the yearly development for the ten most frequently used drug classes in 2012, measured in DDDs per person per year from 2000 to 2012. All ten drug classes follow the same development over time among heavy drug users and the general population, with diuretics (C03) and mineral supplements (A12) slightly decreasing in use and the remaining eight drug classes increasing in use. The use of lipid modifying agents (C10) increased the most both among heavy drug users (11.8-fold) and in the general population (13.4-fold) from 2000 to 2012.

Discussion

Our study is the first study focusing on the group of heavy drug users as the top 1 percentile in a population. It uncovered that heavy drug users among persons aged 60 years and above in Denmark account for a large share of total drug expenditure, as well as an even larger share of public drug expenditure. Importantly, a handful of drug classes can explain a large share of their prescription drug use, and the use has followed the same development over the years studied among both heavy drug users and in the general population.
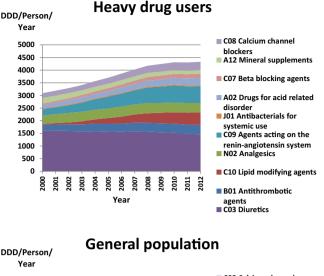
The majority of the heavy drug users for each year were women, and being female has previously been associated with increased use of drugs [1–8, 10]. However, previous findings show that when adjusting for health factors, gender differences are reduced to insignificant levels [6, 7]. A Swedish study showed that the relative risk of redeeming five or more drugs for women compared to men peaked at the age of 20–29 years and then declined rapidly with increasing age [5].

A surprising finding was that the proportion of men was higher among heavy drug users and being male associated with being a heavy drug user in a multivariable model. It is possible that men are more heavily burdened by chronic disease among the very ill proportion of the population. The model is provisionary and, therefore, the increased risk of heavy drug use for men may be overestimated. What further supports this finding is that the proportion of females among heavy drug users decreased by 8.2 % points, from 58.7 % in 2002 to 50.5 % in 2012. This remarkable fall over only 10 years could imply a change in women's health status and/or changes in guidelines for therapy disproportionally affecting the genders.

Table 3 Drug utilization patterns and costs for the ten most frequently used (A) drug classes and (B) drug compounds based on number of users among heavy users of drugs in year 2012 compared to that of the general population

ATC-code	Name	Number of users among heavy drug users [n] (%)	Percent females	Prevalence proportion ratio[a]	Drug expenditure [mill DKK] (% reimbursed)		Heavy drug users' share of drug expenditure	Public drug expenditure [mill DKK]		Heavy drug users' share of public drug expenditure
					Heavy drug users	Total population		Heavy drug users	Total population	
(A) Drug class										
C03	Diuretics	10,486 (87.9 %)	50.5 %	3.2	11.20 (85.7 %)	157.63 (60.9 %)	7.1 %	9.60	96.00	10.0 %
B01	Antithrombotic agents	9725 (81.5 %)	47.4 %	2.5	10.84 (88.6 %)	311.27 (68.0 %)	3.5 %	9.60	211.66	4.5 %
C10	Lipid-modifying agents	9329 (78.2 %)	48.0 %	2.3	11.26 (85.8 %)	233.84 (66.5 %)	4.8 %	9.66	155.50	6.2 %
N02	Analgesics	9263 (77.6 %)	56.0 %	2.9	36.16 (88.0 %)	353.73 (73.5 %)	10.2 %	31.82	259.99	12.2 %
C09	Agents acting on the renin-angiotensin system	8753 (73.4 %)	47.2 %	2.0	3.77 (73.0 %)	143.00 (44.9 %)	2.6 %	2.75	64.21	4.3 %
J01	Antibacterials for systemic use	7960 (66.7 %)	54.3 %	1.9	5.71 (83.9 %)	128.77 (56.9 %)	4.4 %	4.79	73.27	6.5 %
A02	Drugs for acid related disorders	7766 (65.1 %)	55.5 %	3.2	3.61 (67.4 %)	65.02 (48.0 %)	5.6 %	2.43	31.21	7.8 %
C07	Beta-blocking agents	7077 (59.3 %)	45.0 %	2.9	4.41 (78.9 %)	123.19 (53.5 %)	3.6 %	3.48	65.91	5.3 %
A12	Mineral supplements	6793 (56.9 %)	54.1 %	5.5	6.40 (85.3 %)	74.31 (66.9 %)	8.6 %	5.46	49.71	11.0 %
C08	Calcium channel blockers	6546 (54.9 %)	49.5 %	2.5	3.28 (83.8 %)	80.83 (59.1 %)	4.1 %	2.75	47.77	5.8 %
(B) Drug compound										
C03CA01	Furosemide	8423 (70.6 %)	50.4 %	7.0	5.53 (84.3 %)	32.06 (72.7 %)	17.2 %	4.66	23.31	20.0 %
N02BE01	Paracetamol	7887 (66.1 %)	57.6 %	3.5	4.89 (82.9 %)	86.94 (68.4 %)	5.6 %	4.05	59.47	6.8 %
B01AC06	Acetylsalicylic acid	7879 (66.0 %)	47.3 %	2.6	2.36 (86.1 %)	81.51 (57.7 %)	2.9 %	2.03	47.03	4.3 %
A12BA01	Potassium chloride	6641 (55.7 %)	53.7 %	5.8	6.14 (88.0 %)	67.78 (72.2 %)	9.1 %	5.40	48.94	11.0 %
C10AA01	Simvastatin	6554 (54.9 %)	48.5 %	2.0	0.99 (80.0 %)	40.22 (48.2 %)	2.5 %	0.79	19.39	4.1 %
C07AB02	Metoprolol	4797 (40.2 %)	46.7 %	2.8	3.18 (77.5 %)	93.81 (52.1 %)	3.4 %	2.46	48.88	5.0 %
C08CA01	Amlodipine	4790 (40.2 %)	48.4 %	2.3	0.65 (77.3 %)	25.47 (43.7 %)	2.6 %	0.50	11.13	4.5 %
N02AX02	Tramadol	4331 (36.3 %)	56.2 %	3.5	2.78 (85.7 %)	42.76 (69.5 %)	6.5 %	2.38	29.72	8.0 %
A10BA02	Metformin	3958 (33.2 %)	43.9 %	4.2	1.60 (84.0 %)	31.79 (61.3 %)	5.0 %	1.34	19.49	6.9 %
J01CE02	Phenoxymethylpenicillin	3415 (28.6 %)	51.4 %	1.9	0.47 (88.1 %)	16.95 (48.4 %)	2.8 %	0.41	8.20	5.0 %

[a] Ratio between proportion of users among heavy drug users and users in the general population

ATC anatomical therapeutic chemical, *DDD* defined daily dose

Heavy drug users

DDD/Person/
Year

C08 Calcium channel blockers
A12 Mineral supplements
C07 Beta blocking agents
A02 Drugs for acid related disorder
J01 Antibacterials for systemic use
C09 Agents acting on the renin-angiotensin system
N02 Analgesics
C10 Lipid modifying agents
B01 Antithrombotic agents
C03 Diuretics

General population

DDD/Person/
Year

C08 Calcium channel blockers
A12 Mineral supplements
C07 Beta blocking agents
A02 Drugs for acid related disorder
J01 Antibacterials for systemic use
C09 Agents acting on the renin-angiotensin system
N02 Analgesics
C10 Lipid modifying agents
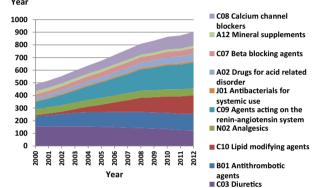B01 Antithrombotic agents
C03 Diuretics

Fig. 1 Yearly development of the ten most used drug classes (i.e., therapeutic subgroups) among heavy drug users shown in DDD/person/year from year 2000 to 2012 compared to the general population (NB! Varying values on the y-axes)

The majority of heavy drug users was in the age group 60–69 and then decreased with increasing age. This coincides with a Swedish study where the highest acquisition cost for individuals with five or more dispensed prescriptions in 2006 was found in the age group 60–69 [11]. However, the proportion of heavy drug users in the age groups 70–79 and 80–89 years was higher than in the general population. This may indicate that as heavy users grow older, they incur a disproportionately higher number of chronic diseases or more complex drug regimens than their peers in the general population.

A larger proportion of heavy drug users were found in North Denmark and a smaller proportion were found in the capital area. These differences remained in multivariable analysis which implies that the skewed distribution across the regions is due to other factors such as health status, travel distance to medical care, patterns in elderly care, or prescribing patterns.

The majority of heavy drug users had short education and low income, agreeing with previous studies [3, 6–8]. Having a short education may suggest less knowledge about the

influence of lifestyle and environmental factors on health. Lower income may lead to seeking medical care rather than buying OTC drugs or dietary supplements as physician consultation is fully covered by the public health insurance in Denmark and most OTC drugs will cost less if purchased on prescription.

The ten most frequently used drug classes among heavy drug users were similar to previous findings [11, 13]. Subgroups of cardiovascular drugs account for five of the ten most frequently used drug classes among heavy drug users in 2012, and these five drug classes or subgroups within the drug classes were all reported to have undergone a considerable growth in population treatment prevalence among persons aged ≥30 years in Denmark during 1996–2005 [25].

In our study, the percentage of public drug expenditure was higher among heavy prescription drug users compared to the general population. This can be expected due to the structure of the Danish reimbursement system which has a ceiling on yearly personal expenses [24]. This is in accordance with findings from Sweden showing that persons who redeemed ≥20 prescription drugs amounted to 1 % of the population and accounted for 10.5 % of total expenditures [5].

The main strength of this study is that it uses nationwide registers containing high-quality data which ensures complete coverage and validity [16–20, 22]. However, there are a few limitations. This study does not include drugs used in hospitals which in 2007 accounted for two fifths of public health insurance spending [26]. Since the indication for treatment for prescribed drugs is not always recorded in the Danish National Prescription Registry [20], this study does not include information on health status which has an impact on prescription drug use [6, 27]. We chose to use hospitalization as a crude measure for the level of morbidity. Certain drugs can be purchased over the counter in Denmark, and drug use and costs are therefore slightly underestimated. Data on education was missing for almost 20 % in 2002 and 4 % in 2012, but as the pattern was similar for all 3 years, the missing data probably did not affect the results considerably.

Conclusion

In this study, being male was associated with heavy prescription drug use both with respect to the number of drugs used and total and public drug expenditures, which is at odds with previous findings. Elderly who are heavy users of prescription medicines account for a relatively much larger share of the drug use and budget, but this difference is decreasing. Further research is needed to investigate whether health conditions and treatment patterns can explain why heavy drug users require a higher number of prescription drugs, the gender differences, and the large regional differences. Further, it is

important to study whether the decreasing share over time attributed to heavy users relates to these same explanatory factors.

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