Differences in medication usage of dental patients by age, gender, race/ethnicity and insurance status

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ABSTRACT

BACKGROUND: Limited studies have investigated the medication profile of young adult dental patients despite the high prevalence of prescription opioid abuse in this population.

OBJECTIVE: This study investigated the extent and differences in medication usage of dental patients older than 18 years by age, race/ethnicity, gender, insurance status and mechanism of action in an academic dental clinic setting.

METHODS: Using an automated approach, medication names in the Electronic Dental Record were retrieved and classified according to the National Drug Code directory. Descriptive statistics, multivariable ANOVA and Post hoc tests were performed to detect differences in the number of medications by patient demographics.

RESULTS: Of the 11,220 adult patients, 53 percent reported taking at least one medication with significant differences in medication usage by demographics. Hydroxymethylglutaryl-coenzyme A reductase inhibitors (21-36%), and angiotensin-converting enzyme inhibitors (19-23%) ranked the top two medication classes among patients 55 years and older. Opioid agonists (7-14%), and Selective Serotonin Reuptake Inhibitors (SSRIs) (5-12%) ranked the top two medication classes among patients aged 18-54 years.

CONCLUSIONS: The results underscore the importance of dental providers to review medical and medication histories of patients regardless of their age to avoid adverse events and to determine patient's risk for opioid abuse.

1. BACKGROUND

In the past decade, there has been a significant increase in the percentage of US population who reported taking medications. Among this population, 35% of adults aged 20 to 39 years old reported taking at least one prescription medication, while 36% of adults 65 years and older reported taking at least five prescription medications [1]. As a result, dental clinicians are managing more patients who take prescription medications. Three recent studies examining medication usage in dental patients 65 years and older reported 53-76% of patients taking at least one medication [2-4]. These studies also found antihypertensive medications, and psychiatric medications as the top medications taken by their patients. They highlighted the necessity to pay close attention to the medication history of adult dental patients 65 years and older [2-4]. However, limited studies have investigated the medication profile of young adults despite the high prevalence of prescription opioid abuse and high rate of antidepressant use for mental health issues among this population in the United States. Determining medication usage among patients by age, race/ ethnicity, gender, and insurance status would enable dental practitioners, and researchers to investigate differences in health outcomes and recommend effective plans to improve outcomes [5, 6].

Research suggest that medications, especially those that cause dry mouth (xerostomia) can increase an individual's risk for dental caries, oral fungal infection, and also compromise dental treatment outcomes [7-9]. Understanding the mechanism of action and side effects of medications would enable dental practitioners to manage their effect on oral health and to avoid potential adverse drug reactions [2, 10]. Therefore, it is important to classify medications based on their mechanism of action to investigate the underlying biological and pharmacological pathways that affect a person’s oral health. For example, antihypertensive medications with different mechanisms of action can lead to different oral manifestations such as xerostomia and

gingival hyperplasia [11-13]. However, except for one study [3], all other studies reported dental patients' medication usage based on their medical condition [2-4].

The high adoption of electronic dental record (EDR) since last decade offers an opportunity to access patients' clinical information electronically [14]. This information could be utilized to examine dental patients' medication use. However, patients' self-reported medication information is often stored in free-text format, which is usually analyzed through manual review. Manual chart review is time consuming, error prone, and allows review of only a limited number of patient record data. Text-mining is an advanced computational approach, which can facilitate extraction of relevant information automatically from electronically recorded free-text data. The advantage of utilizing this method is that it allows information retrieval from a large number of records efficiently and accurately. In medicine, many studies have successfully characterized patients' medication profile through automated retrieval of medication information written as free-text in electronic health records [15, 16]. In this study, we utilized a text mining approach that allowed automated retrieval of medication information from the EDR.

2. OBJECTIVE

The primary objective of this study was to examine the extent and differences of medication usage by patient demographics (age, race/ ethnicity, gender, and insurance status) and mechanism of action using a large patient cohort in an academic dental setting. A second outcome of this study is the development of a process to automate retrieval of medication names from EDR data.

3. METHODS

The Indiana University Purdue University Indianapolis Institutional Review Board (1604548307) approved the study. We conducted a retrospective study of 11,220 dental patients, which included the following steps: generating a patient cohort; building a dictionary of lexical variants

of medication names; mapping lexical variants to standard medication names, automated retrieval of medication terms, and data analysis.

3.1. Generating a patient cohort

We retrieved medication histories from the EDR of patients 18 years and older who underwent a comprehensive oral evaluation (COE) (Code on Dental Procedures and Nomenclature: D0150) between January 1, 2009, and December 31, 2011. All patients are required to have a complete medical and medication history upon completion of COE. The resulting limited data set consisted of 11,220 unique patient records. We retrieved information recorded in response to the following three questions: “Do you take any medications?”; “What medications are you currently taking?” and “Have you taken any other medication in the past 5 years?” We observed that the information related to medications were documented in all three fields.

3.2. Building a dictionary of lexical variants of medication terms

The purpose of constructing this dictionary was to capture all variants of documented medication names (henceforth referred as lexical variants in this paper), which included standard medication names, alternate spellings, abbreviations, and acronyms. To create this dictionary, we tokenized the texts in response to the three questions and removed duplicated medication names. Therefore, even though the medication name is reported in response to all the questions, it was considered once. Tokenization is the process of splitting text into smaller units called tokens. In this study, we split the sentences into individual words to retrieve the medication names (see Figure 1). We manually reviewed the resulting list to confirm the dictionary contained only medication terms or names.

3.3. Mapping lexical variants to standard vocabulary of medication names

Next, we mapped the lexical variants to a standard vocabulary, the National Drug Code (NDC) directory developed by the Food and Drug Administration (FDA). The Drug Listing Act of 1972 requires all registered drug establishments to provide an up-to-date list of drugs that are

manufactured for commercial distribution to the FDA. Medication names (brand, generic and substance) and other information such as pharmacology class and product type are submitted to the FDA and is then published online in the NDC directory. We utilized the Fuzzy LookUp function (Microsoft Research) to map the medication names to the NDC directory. The Fuzzy Lookup function is a fuzzy matching algorithm that matches lexical variants of a word such as spelling errors, abbreviations and synonyms to the correct word. Through this process, we mapped each medication term to its standard drug name (brand, generic and substance), drug class and product type (see Figure 1). Three researchers independently reviewed the mapped medication names and found Fuzzy LookUp function correctly mapped 96.52% (5375/5569) of the medication names. They resolved the remaining 194 mismatched names through discussion and consensus.

3.4. Automated retrieval of the medication terms from the EDRs

Using the mapped lexical variants, we developed a program that uses regular expressions derived from the mapped lexical variants to retrieve medication names from the medication histories in 11,220 patient records. The program also mapped the lexical variants to the correct drug name (brand name, generic name and substance name), drug class and type as presented in the NDC directory.

3.5. Data analysis

The medication names from 11,220 patient records were classified according to their substance name and pharmacologic class presented in the NDC directory. We performed descriptive statistics to estimate the total number of medications, mean number of medications and percentage of patients who took medications stratified by gender, race/ethnicity, and age. We also determined the top ten prescription medications taken by patients. We performed multivariable ANOVA (analysis of variance) and post hoc test to detect any difference in the number of medications by age group, gender, race, and insurance status. To perform this test

by gender, we grouped male, transgender, and unknown together and compared them with female patients. Similarly, for race, we grouped those patients who didn't report (unknown) or didn't specify (unspecified) as unknown and grouped those who reported Asian, American Indian/Alaskan, Bi-racial/Multi-racial, and Native Hawaiian/Pacific Islander as 'other'. Statistical significance was defined at $p < 0.05$. All statistical analyses were performed using SPSS statistics (IBM Corporation, Inc. Armonk, NY).

4. Results

4.1. Medication usage by age, gender, race/ethnicity

The mean age of the patients in this study was 45.4 years (Standard Error of Mean (SEM): 0.16). This study population consisted of more female patients (53.3%) than male patients (Table 1). Caucasians accounted for more than half (54.6%) of this patient population. More than half of the patients (59%) did not have dental insurance. A total of 25,905 medications were retrieved from 11,220 unique patient records. Of the 25,905 medications, the majority of the medications were prescription medications (74.73%) and the remaining over-the-counter (OTC) medications (24.77%). The mean number of medications per patient was 1.73 for prescription medications and 2.31 for both prescriptions and OTC medications combined. As displayed in Table 2, 5,917 (53%) patients reported taking at least one medication while 5,303 (47%) patients did not report taking any medication. Approximately 30 percent of patients reported taking 1 to 3 medications. The number of medications patients took were significantly different by age group, gender, race, and insurance status. For the age group, post-hoc tests indicated that the number of medications significantly increased in the following order: 18-24 years & 25-34 years < 35-44 years < 45-54 years < 55-64 years< 85+ years & 65-74 years & 75-84 years ($p \leq 0.001$) (Table 1). For race, post hoc tests demonstrated that the number of medications increased in the order: Hispanics & Others < Unknown & African Americans < and

Caucasians ($p<0.05$). Females took significantly more medications ($p<0.001$), and patients with insurance took significantly more medications than those without insurance ($p<0.001$) (Table 1).

4.2. Top prescription medications, and top pharmacologic class of prescription medications

The top ten prescription medications that patients reported taking are illustrated in Table 3. Lisinopril, hydrocodone bitartrate + acetaminophen, and simvastatin were the top three medications reported among 11,220 patients. Table 3 reports the number of patients taking the top ten pharmacologic classes of prescription medications. HMG-CoA Reductase Inhibitor, Opioid Agonist, and Serotonin Reuptake Inhibitor (SSRI) were the top three pharmacologic classes of medications reported by patients.

4.3. Top pharmacologic classes of prescription medications stratified by age

Stratifying prescription medication classes by age revealed medication profiles of patients across the eight age groups (see Figure 2). HMG-CoA reductase inhibitors (21-36%), angiotensin-converting enzyme inhibitors (19-23%) and beta- adrenergic blockers (12-29%) remained the top three medication classes among patients 55 years and older (see Figure 2) while 0-11% of patients reported taking these medication classes among patients between ages 18-54 years. Opioids (7-14%), and SSRIs (5-12%) ranked as the top two pharmacologic classes of medications taken by patients in the age group 18-54 years (Figure 2) with beta 2-Adrenergic Agonist (4-7%) class of medications ranked third among patients aged between 18 and 44 years.

5. Discussion

This study determined the self-reported medication usage of a large cohort of 11,220 adult dental patients from their EDR data. Significant findings include more than half of the patients (N=5,917, 53%) reported taking at least one medication and significant differences existed in their medication profile by age, race/ethnicity, gender, and insurance. Patients belonging to all

age groups reported taking medications although patients 55 years and older and Caucasians took more medications (see Table 1). While patients 55 years and older took medications mostly for chronic disease management, 12-26% of patients aged 18-54 years reported taking medications belonging to opioid agonist, and SSRI medication classes (Figure 2). The results highlight the need to pay close attention to dental patients' medication history regardless of their age to prevent adverse events during dental care, assess their risk for opioid dependence, and the medications' effect on a patient's oral and overall health.

As reported in the results, the demographics (mean age: 45.4 years and 56% females) of the study population were similar to that reported in previous studies where the study population ranged from 322 to 1,797 patients. While Radfar et al. reported similar percentage (54%) of patients taking at least one medication [4], Guggenheimer et al. [2] and Fitzgerald et al. [3] reported higher percentage of patients (63-77%) taking at least one medication. These differences could be due to differences in the study population across studies. For example, Fitzgerald et al. included only patients who visited a periodontal specialty clinic that comprised of patients mostly 65 years and older [3]. Antihypertensive medications were the most often reported medications similar to results from these three studies. However, when classifying medications by mechanism of action, we found medications belonging to the HMG-CoA reductase inhibitors (lipid lowering medications) as the most common medication among our patient population.

Similar to studies in medicine, patients belonging to Hispanic, African American, and other racial/ethnic minority groups took significantly fewer medications than Caucasians [6, 17, 18]. Previous studies have reported that people belonging to minority race/ethnic groups utilize fewer healthcare and dental services compared to Caucasians [19-23] and has limited insurance coverage [24, 25]. Our study also demonstrated that females took more medications than males. This finding could be due to several reasons. First, females are more aware of their health and tend to utilize health services more often than males. Second, females are more

adherent to treatment recommendations than males [26]. Third, females are used to preventive management programs because of the availability of programs such as breast and cervical cancer screenings developed solely for females. These variations found in the access and utilization of medical care and medication usage by race/ethnicity, gender and insurance coverage may lead to significant differences in health outcomes and healthcare costs [6].

As Table 1 shows, we found significant differences in the number of medications with increasing age group except for patients 85 years and older who took fewer medications than patients in the 65-84 years age. These results indicate polypharmacy is common with increasing age similar to that reported in previous studies [17, 27]. Moreover, compared to younger patients, older patients often suffer from complex and multiple systemic conditions leading to negligence to seek dental care [4]. The high percentage of medication usage that cause xerostomia among older population warrant further studies regarding these medications' influence on modifying the risk for oral diseases such as dental caries.

It is noteworthy that about 49% of patients who took medications were less than 45 years old (0.92 medications per patient). Pain medications (opioid analgesics) and anti-depressants (SSRI) were the most common medications among this age group. This finding is not surprising considering the high prevalence of prescription opioid abuse among young adults in the United States (Substance Abuse and Mental Health Services Administration [28]). Also, the high rate of SSRI use coincides with the rise of antidepressant use in the United States. From 1988–1994 through 2005–2008, the rate of antidepressant use in the United States among all ages increased nearly 400% [29]. This high opioid and SSRI use in our study population is probably because young adults with systemic diseases tend to seek dental care in larger healthcare settings than in private practices. This finding also indicates that dental providers could identify individuals at high risk for opioid abuse through a careful review of their patients' medical and medication history.

Many of the frequently used medications negatively affect oral health and treatments. For instance, medications such as ACE inhibitors and beta blockers, ranked as 4 and 6 most common medication class, are xerogenic. These medications are associated with higher incidences of crown and root restorations, suggesting a higher propensity of inducing caries [8]. Based on these findings, dentists should be vigilant about the medical conditions and medication usage of both younger and older adult patients. As evident by our study, both groups reported taking high number of medications. In-depth medical and medication history should be taken for every patient regardless of their age to assess their overall health and avoid potential adverse events during care, and medication side effects such as xerostomia that may affect oral health and dental treatments.

In contrast to previous studies that performed manual review and surveys to characterize patients' medication profiles, our study utilized an automated approach to retrieve medication information from a larger patient population. In addition, instead of classifying medications based on therapeutic use, we classified medications based on their medication class standardized by a known drug vocabulary. Classifying medications based on their medication classes enable us to determine the chemical pathways that form the basis for drug action and its side effects.

There are also several limitations within our study that need to be addressed. First, the lexical variants of medications were captured from the EDR of patients in the Indiana University School of Dentistry. This dictionary could serve as baseline vocabulary for lexical variants of medications but may not fully represent how medications are documented at other institutions or clinics. Second, the medications were self-reported by patients, which may not be an exact representation of medication usage and subject to recall bias. Third, the study population sought dental care in an academic institution. While our patients covered a wide range of demographics including multiple races and age groups, it may not be an exact representation of the general population. Finally, we did not retrieve the dosage and duration of medications.

Future work includes retrieving the dosage and duration of medications from medication histories. Additionally, our algorithm's performance could be evaluated on a larger dataset and datasets from other organizations. Furthermore, patients' medication usage extracted from EDR data could be compared to pharmacy or prescription data to determine the validity of medication information reported by patients.

6. CONCLUSION

This study demonstrated significant difference in medication usage based on patient demographics (age, race/ethnicity, gender, and insurance status). The study results stress the importance of taking detailed medical and medication history of all patients regardless of their age before planning dental treatment to avoid potential adverse events or complications.

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8. DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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TABLES

Table 1: Patient demographics and mean number of medications stratified by gender, race/ethnicity and insurance.

Age	N	%	Mean	SEM
18-24	1429	12.7	0.8	0.0
25-34	2307	20.6	1.0	0.0
35-44	1786	15.9	1.7	0.1
45-54	2356	21.0	2.5	0.1
55-64	1774	15.8	3.4	0.1
65-74	1019	9.1	4.8	0.2
75-84	469	4.2	5.0	0.3
85+	80	0.7	4.7	0.6
Gender				
Female	5,976	53.3	2.6	0.1
Male	5,211	46.4	2.0	0.01
Unknown	26	0.2	2.7	0.9
Transgender	7	0.1	1.4	0.4
Race/Ethnicity				
Caucasian/White	6,123	54.6	2.5	0.1
Unspecified	2,704	24.1	2.3	0.1
African American/Black	1,445	12.9	2.3	0.0
Hispanic/Latino	596	5.3	0.8	0.0
Asian	248	2.2	1.0	0.1
Other	60	0.5	0.8	0.3

Bi-Racial/Multi-Racial	20	0.2	1.6	0.6
Unknown	15	0.1	1.5	0.7
American Indian/Alaskan	7	0.1	4.7	2.2
Nat Hawaiian/ other Pacific Islanders	2	0.0	0	0
Insurance (Yes/No)				
Yes	4,601	41.0	2.6	0.2
No	6,619	59.0	2.1	0.0

Table 2: Patient distribution by number of medications.

Number of medications	Number of patients	%
0	5,303	47.3
1 to 3	3,320	29.6
4 to 6	1,355	12.1
7 to 9	623	5.6
10 to 12	313	2.8
13 to 15	162	1.4
16+	144	1.3
Total	11,220	100

Table 3: Top 10 prescription medications, and medication classes by frequency of patient usage.

Rank	**Medication names**	**Number of patients**	**%**
1	Lisinopril	859	7.7
2	Hydrocodone Bitartrate; Acetaminophen	635	5.7
3	Simvastatin	590	5.3
4	Levothyroxine Sodium	554	4.9
5	Metformin Hydrochloride	491	4.4
6	Albuterol Sulfate	420	3.7
7	Metoprolol Tartrate	333	3.0
8	Amlodipine Besylate	332	3.0
9	Esomeprazole Magnesium	306	2.7
10	Valsartan; Hydrochlorothiazide	285	2.5
Rank	**Medication classes**	**Number of patients**	**%**
1	HMG-CoA Reductase Inhibitor	1,222	10.9
2	Opioid Agonist	1,210	10.8
3	Serotonin Reuptake Inhibitor	1,089	9.7
4	Angiotensin Converting Enzyme Inhibitor	1,060	9.5
5	Proton Pump Inhibitor	1,030	9.2
6	beta-Adrenergic Blocker	859	7.7
7	Thiazide Diuretic	723	6.4
8	beta2-Adrenergic Agonist	718	6.4
9	Angiotensin 2 Receptor Blocker	689	6.1
10	Calcium Channel Blocker	573	5.1

FIGURE LEGEND

Figure 1: Steps involved in tokenizing, mapping and standardizing medication terms from medication histories in the Electronic Dental Records NDC: National Drug Code directory.

Figure 2: Rate of medication usage for the top 10 medication classes across the eight age groups.

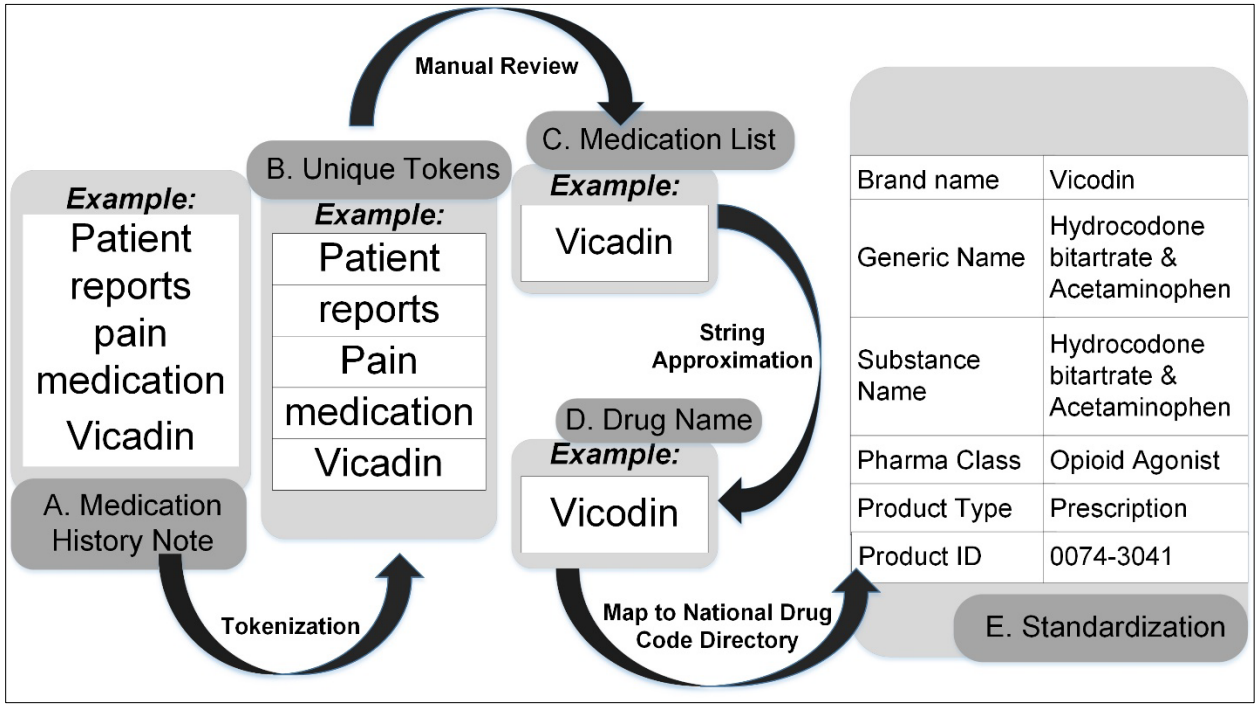
Manual Review
C. Medication List
B. Unique Tokens
Example:
Patient reports pain medication Vicadin
Example:
Patient
reports
Pain
medication
Vicadin
Example:
Vicadin
String Approximation
D. Drug Name
Example:
Vicodin
A. Medication History Note
Tokenization
Map to National Drug Code Directory
Brand name
Vicodin
Generic Name
Hydrocodone bitartrate & Acetaminophen
Substance Name
Hydrocodone bitartrate & Acetaminophen
Pharma Class
Opioid Agonist
Product Type
Prescription
Product ID
0074-3041
E. Standardization

Figure 1

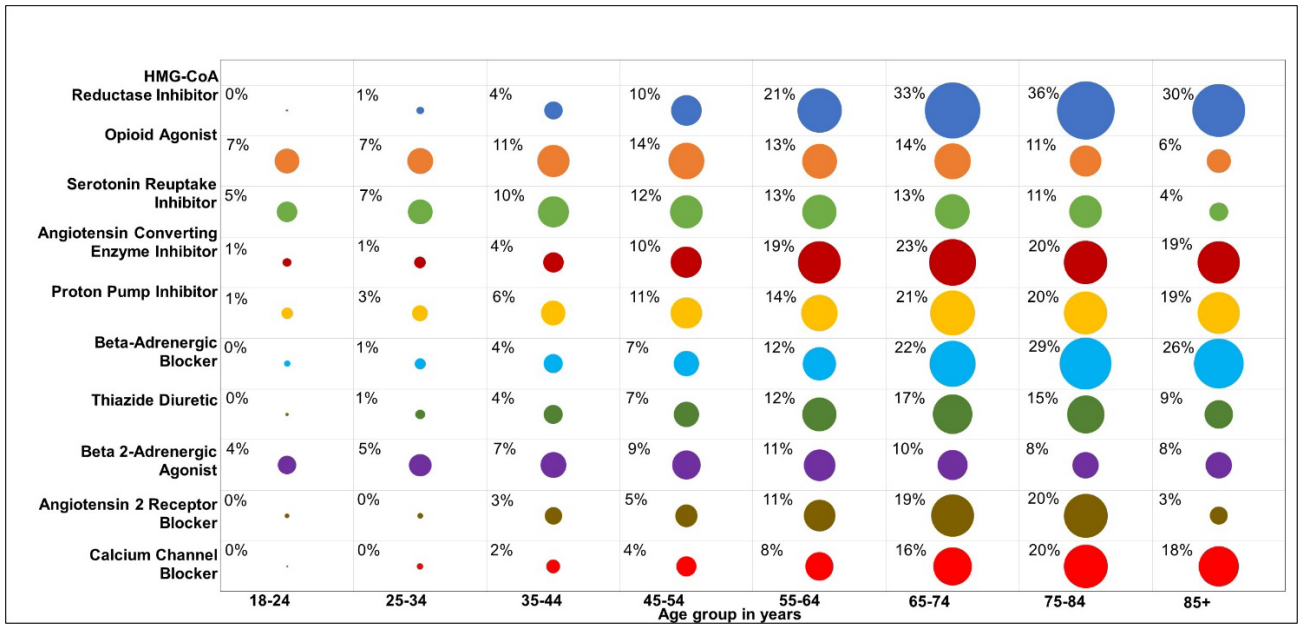
HMG-CoA Reductase Inhibitor
Opioid Agonist
Serotonin Reuptake Inhibitor
Angiotensin Converting Enzyme Inhibitor
Proton Pump Inhibitor
Beta-Adrenergic Blocker
Thiazide Diuretic
Beta 2-Adrenergic Agonist
Angiotensin 2 Receptor Blocker
Calcium Channel Blocker
0% 1% 4% 10% 21% 33% 36% 30%
7% 7% 11% 14% 13% 14% 11% 6%
5% 7% 10% 12% 13% 13% 11% 4%
1% 1% 4% 10% 19% 23% 20% 19%
1% 3% 6% 11% 14% 21% 20% 19%
0% 1% 4% 7% 12% 22% 29% 26%
0% 1% 4% 7% 12% 17% 15% 9%
4% 5% 7% 9% 11% 10% 8% 8%
0% 0% 3% 5% 11% 19% 20% 3%
0% 0% 2% 4% 8% 16% 20% 18%
18-24
25-34
35-44
45-54
55-64
65-74
75-84
85+
Age group in years

Figure 2