Association of a Controlled Substance Scoring Algorithm with Health Care Costs and Hospitalizations: A Cohort Study

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ABSTRACT

BACKGROUND: Patients often misuse a combination of prescription drugs including opioids; however, the relationship between a controlled substance (CS) score and health outcomes is unknown.

OBJECTIVE: To examine the association between a CS scoring algorithm and health care use, specifically total cost of care, hospitalizations, and emergency room (ER) visits.

METHODS: This analysis was a retrospective cohort study using administrative claims data from a large U.S. health insurer. Included in the analysis were 999,852 members with a minimum CS score of 2.5 in the fourth quarter (4Q) of 2012, who were continuously enrolled from January 1, 2012, to December 31, 2013, and who were aged 18 years or older. A CS score was calculated using 4Q 2012 (3 months) prescription claims data and divided into 3 components: (1) number of CS claims, (2) number of unique pharmacies and unique prescribers, and (3) evidence of increasing CS use. The primary outcomes were total cost of care (pharmacy and medical costs), all-cause hospitalizations, and ER visits in 2013. We also quantified what a 1-point change in CS score meant for the primary outcomes.

RESULTS: 47% of members had a CS score of 2.5, indicating a single CS claim, and 51% of members had a score between 3 and less than 12. The remaining 2% (20,858 members) had a score of 12 or more. There was a statistically significant and consistently increasing association between the 4Q 2012 CS score and hospitalizations, ER visits, and total costs of care in 2013. A 1-point change in CS score was associated with a \$1,488 change in total cost of care, 0.9% change in the hospitalization rate, and 1.5% change in the ER visit rate.

CONCLUSIONS: There is a linear association between increasing CS score and negative health outcomes. Insurers should consider interventions to lower member CS scores.

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- Previous research has shown that identifying members using a CS score and intervening by mailing prescribers a letter was associated with a statistically significant reduction in CS score; however, the CS scoring algorithm has not been validated.

What this study adds

- This study validates an association between a CS score and hospitalizations, emergency room (ER) visits, and health care costs.
- Outcomes of this analysis demonstrate a linear relationship between a CS score and outcomes; for each 1-point CS score change, total cost of care changed \$1,488, all-cause hospitalizations rates changed 0.9%, and rate of ER visits changed 1.5%.

Prescription drugs are the third most commonly abused category of drugs, behind alcohol and marijuana and ahead of cocaine, heroin, and methamphetamines.¹ Some of the most commonly abused prescription drugs include opioid pain relievers, such as hydrocodone- or oxycodone-containing products. Other frequently abused prescription drugs include stimulants for treating attention deficit hyperactivity disorder, such as methylphenidate- or dextroamphetamine-containing products, and central nervous system depressants for relieving anxiety, such as benzodiazepines.^{1,2} More than half of drug overdose deaths involve prescription drugs, with the majority due to opioid painkillers.³

While most research has focused only on opioid use, it is important to understand that opioid abusers frequently use other controlled substances (CS) concomitantly, increasing their risk of overdose and death.^{4,5} For example, the risk of a lethal outcome is higher when opioids are used in combination with benzodiazepines.⁶ A 2013 report found that among patients using opioids for at least 30 days, 30% of patients had benzodiazepines prescribed in the same month; 28% had been prescribed muscle relaxants; and 8% were prescribed all 3.⁷ Moreover, an analysis of 1,295 poison center cases between 1998 and 2009 found that concomitant use of hydrocodone, alprazolam, and carisoprodol was considered the cause of moderate (24%) and major (11%) clinical effects and 9 fatalities (0.3%).⁸

The prescription drug overdose crisis continues to grow. In February 2016, President Barack Obama proposed over a billion budget dollars to help address the problem. The president's

What is already known about this subject

- Prescription drugs are the third most commonly abused category of drugs, and while most research has focused only on opioid use, it is important to understand that opioid abusers frequently use other controlled substances (CS) concomitantly, which increases their risk of overdose and death.
- Insurers and pharmacy benefit managers use a variety of methods to educate and alert providers about CS use behavior of members, including retrospective drug utilization reviews and provider mailings, which are low cost and have mixed results on changing prescribing practices.

TABLE 1 Controlled Substance Score Components

Data Source	Volume of CS Claims	Number of Unique Pharmacies and Prescribers	Rate of CS Utilization
Three months of administrative pharmacy claims data	Assign half a point to the individual for each of first 8 claims for a CS; assign 1 point for each additional CS claim thereafter.	Based on the combined total of unique pharmacies and prescribers, assign 1 point for the first 2 unique entities; assign 1.5 points for each unique entity thereafter.	Assign 1 point if the number of claims for CS in the third month of the 3-month period is 2 or more than the number of claims in the second month of the 3-month period.

From Daubresse M, Gleason PP, Peng Y, Shah N, Ritter ST, Alexander CG. Impact of a drug utilization review program on high-risk use of prescription controlled substances.¹⁰

Note: Minimum score = 2.5 (1 CS claim = 0.5 + 1 unique pharmacy + 1 unique prescriber + 0 for no increased utilization).

CS = controlled substance.

proposal focuses on helping to ensure that all Americans who want treatment can get the help they need, expanding access to medication-assisted treatment for opioid use disorder, and expanding access to substance use treatment providers. In addition, thought leaders in the prescription drug abuse arena encourage comprehensive engagement from all parties involved in health care delivery and payment, including health insurers and pharmacy benefit managers.⁹

Insurers and pharmacy benefit managers use a variety of methods to educate and alert providers about the CS use behavior of their members, such as retrospective drug utilization reviews (RDURs) and provider mailings, which are low cost and have mixed results on changing prescribing practices.¹⁰⁻¹² RDURs require use of pharmacy and/or medical claims data to develop algorithms for identifying potential overuse/abuse. A study by Qureshi et al. (2015) assessed the effect of a prescriber mailing to decrease CS use.¹² Members using high-dose opioids along with another opioid, benzodiazepine, or an antidepressant were identified for intervention. The results showed a 28.1% reduction in potentially unsafe opioid and benzodiazepine use.¹² Additionally, previous research has shown that identifying members using a CS score, developed by Prime Therapeutics, and intervening with a prescriber letter was associated with a statistically significant reduction in CS scores, from 19.0 to 13.7 (34% score reduction) for the intervention group and from 18.6 to 14.3 (26% score reduction) for the control group. The absolute difference in score was a 1- to 1.4-point lowering after 6 months in the intervention, compared with a concurrent control group.^{10,13} Furthermore, the reduction in CS claims resulted in a net CS pharmacy claims savings of \$210,566 or \$0.06 per member per month across more than 1 million commercially insured lives, and prescribers found the program valuable (88% said useful/very useful).^{10,13} However, as noted in an editorial by Coplan (2014), the CS scoring algorithm has not been validated, and it is unknown if the scoring algorithm is associated with changes in health care use and/or costs.¹⁴ The purpose of this study was to determine if the CS scoring algorithm is associated with changes in health care use, specifically hospitalizations or emergency room (ER) visits and total cost of care.

Methods

A retrospective claims analysis was performed using administrative eligibility, medical, and pharmacy claims data from over 11 million commercial members from 11 health plans across the United States. The data are from 1 large pharmacy benefit manager with over 25 million eligible members represented in all 50 states and the District of Columbia. Pharmacy claims data include information on prescription fill date, strength of prescription, quantity dispensed, prescribers, and dispensing pharmacies. Medical claims information includes facility- and professional-based claims and total allowed amounts from the claims (health insurer- and member-paid amounts).

A CS score was computed based on previous research for each member using all CS pharmacy claims found in the fourth quarter (4Q) of 2012 (October 1, 2012–December 31, 2012).¹⁰ The CS score was calculated using a 3-month period of prescription claims data and was divided into 3 components. First, the CS score counted the number of CS claims and assigned 0.5 points for the first 8 CS claims and then 1 point for each additional claim. Second, the number of unique pharmacies and unique prescribers were counted and assigned points, 1 for the first 2 unique entities and 1.5 for each unique entity thereafter. Third, points were assigned to the member if the number of CS claims in the third month of the quarter was 2 or more than in the second month (Table 1).¹⁰ CS prescriptions included opioid analgesics, stimulants, benzodiazepines, barbiturates, sedative-hypnotics, and anabolic steroids from schedules II–V of the U.S. Drug Enforcement Administration's Controlled Substances Act.¹⁵ Figure 1 shows the members eligible for the analysis. Members were required to have a minimum CS score of 2.5 (i.e., at least 1 CS prescription claim), be continuously enrolled from January 1, 2012, to December 31, 2013 (2 years), and be aged 18 years or older as of December 31, 2012.

Characteristics for eligible members were collected using all pharmacy and medical claims from January 1, 2012, through December 31, 2012. Member characteristics included age, gender, ZIP code, level of education, income, and race (derived from U.S. Census Bureau information); an Optum Symmetry Pharmacy Risk Group score (an industry-accepted software tool

FIGURE 1 Flow of Members in the Analysis

CS=controlled substance.

that uses pharmacy claims data to predict future health care cost and prescription use^{16,17}; a Charlson Comorbidity Index score (a medical claims-based mortality risk indicator)¹⁸; total allowed amounts for all pharmacy and medical claims; ER visits using revenue codes found on medical claims; hospitalizations using revenue codes found on medical claims; and region of the country (Midwest or South). Income, race, and education assignment at the ZIP-code level was performed because actual income and education data were unavailable for members.

For outcomes, all pharmacy and medical claims data were queried from January 1, 2013, through December 31, 2013, to identify the following: (a) total allowed amounts for all pharmacy and medical claims (health insurer plus member paid), (b) ER visits using revenue codes found on medical claims, and (c) hospitalizations using revenue codes found on medical claims.

Statistical Analysis

Descriptive analyses were used for member characteristics and unadjusted total cost of care by the CS score groups. The CS score groups were created to allow analyses of a 1-point CS score change on hospitalizations, ER visits, and total cost of care. The minimum CS score of 2.5 (i.e., members with 1 CS claim) was the reference group. After the CS score of 2.5, groups increased by 1 to a score of 20. After a CS score of 20, the groups were combined because of small sample sizes. The final groups were CS scores 21 to <25, CS scores 25 to <30, CS scores 30 to <40, and CS scores of ≥40.

A logistic regression model was estimated to measure the association between 4Q 2012 CS scores and outcomes in 2013 (hospitalizations and ER visits), with adjustment for all member characteristics from 2012. The logistic regression fit was

assessed using the c-statistic. Cost analyses were performed using a generalized linear model with gamma distribution and adjusted for the same covariates previously listed. A Park statistical test was conducted to ensure that the total cost of care data met the assumptions of the gamma model.

To describe the change in health care use and total costs associated with a 1-point CS score change, we ran additional logistic regression and gamma models. These additional models provided adjusted event rates and costs for each CS score group and allowed us to fit a trend line and generate linear regression equations for hospitalizations, ER visits, and total cost of care. Because of the small sample size in the higher CS score groups, we only adjusted for age and gender.¹⁹ All analyses were completed using SAS version 9.3 (SAS Institute, Cary, NC). Statistical significance was set a priori at $P < 0.05$.

Results

Approximately 11 million members across 11 health plans were eligible for study analysis in December 2012. Of these, 5,922,175 (54%) members were continuously enrolled from January 1, 2012, through December 31, 2013. There were 4,922,323 (83.1%) members who did not have any CS claims in the 4Q 2012. The 999,852 (16.9%) members with at least 1 CS claim (i.e., CS score of 2.5 or higher) made up the analysis population. The CS score had a range of 2.5 (i.e., 1 CS claim found) up to a maximum of 115 in the current study. We excluded members with no CS claims whose CS scores were zero. The average CS score in this analysis (excluding zeros) was 4.03, with an interquartile range of 2.5-4.5.

Table 2 shows the baseline member characteristics. The majority of the study sample was female (57%). About 19% of the sample was aged less than 34 years; 25% was aged 34-46 years; 29% was aged 47-56 years; and 26% was aged older than 57 years. Just under half (47%) had a CS score of exactly 2.5, indicating a single CS claim during the 4Q 2012; 51% had a score between 3 and less than 12. The remaining 2% (20,858) of members had a score of 12 or more. The most common CS class used in the 4Q 2012 was opioids (46.5%), followed by benzodiazepines (39.7%), stimulants (10.9%), and anabolic steroids (4.2%). The majority of members had a Charlson Comorbidity Index score of 0-1 (93.8%). The prevalence rate of baseline hospitalization was 9.9%, and rate of ER visit was 23.7%.

The 2013 unadjusted total cost of care by CS score is shown in Figure 2. The median 2013 total cost of care for members with a CS score of 2.5 was \$2,486, with a linear relationship between increased CS score and costs. Members with a CS score of 20-21 had median total medical and pharmacy costs of \$17,709. Median total 2013 health care costs for members in the highest CS score category of 40 or higher were \$32,232.

After multivariate model adjustment (Table 3), we found a statistically significant and consistently increasing association

TABLE 2 Baseline Demographic Characteristics of Members with CS Scores of 2.5 and Higher^a

Characteristic	Members n (%)	Characteristic	Members n (%)
CS score, 4Q 2012		Proportion with bachelor degrees in member ZIP code	
2.5	470,309 (47)	< 17%	260,229 (26)
3 to < 4	190,133 (19)	17% to 24%	223,945 (22)
4 to < 5	96,511 (10)	25% to 39%	255,682 (26)
5 to < 6	78,806 (8)	40% +	259,996 (26)
6 to < 7	55,997 (6)	Median household income in member ZIP code	
7 to < 8	34,376 (3)	< \$43,000	257,732 (26)
8 to < 9	22,376 (2)	\$43,000 to < \$55,000	269,466 (27)
9 to < 10	12,953 (1)	\$55,000 to < \$70,000	214,752 (21)
10 to < 11	10,506 (1)	\$70,000 +	257,902 (26)
11 to < 12	7,027 (1)	Pharmacy Risk Group Scores in 2012	
12 to < 13	4,649 (0)	0 to < 1.2	238,353 (24)
13 to < 14	3,745 (0)	1.2 to < 2	272,147 (27)
14 to < 15	2,796 (0)	2 to < 3.3	237,996 (24)
15 to < 16	2,026 (0)	3.3 +	251,356 (25)
16 to < 17	1,676 (0)	Charlson Comorbidity Index Scores in 2012	
17 to < 18	1,265 (0)	0	834,628 (83)
18 to < 19	961 (0)	1	104,034 (10)
19 to < 20	765 (0)	2	40,399 (4)
20 to < 21	591 (0)	3 +	20,791 (2)
21 to < 25	1,371 (0)	Emergency room visits in 2012	
25 to < 30	640 (0)	No	763,342 (76)
30 to < 40	290 (0)	Yes	236,510 (24)
40 +	83 (0)	Hospitalizations in 2012	
Age, years		No	900,680 (90)
18 to < 34	194,693 (19)	Yes	99,172 (10)
34 to 46	254,399 (25)	Total cost of care (pharmacy and medical costs in 2012)	
47 to 56	291,933 (29)	\$0 to < \$1,600	244,299 (24)
57 +	258,827 (26)	\$1,600 to < \$4,500	260,045 (26)
Female	573,191 (57)	\$4,500 to < \$11,000	235,035 (24)
Male	426,661 (43)	\$11,000 +	260,473 (26)
Proportion of whites in member ZIP code		Region	
< 74%	242,541 (24)	South	588,497 (59)
74% to 85%	279,499 (28)	Midwest	411,355 (41)
86% to 92%	237,410 (24)		
93% +	240,402 (24)		

Note: Values are numbers (percentages) unless otherwise indicated. Percentages may not sum to 100 due to rounding. The income, race, and education variables are all ZIP-code derived.

^aFrom October 1, 2012, through December 31, 2012, N=999,852.

CS=controlled substance; 4Q=fourth quarter.

between the 4Q 2012 CS score and hospitalizations, ER visits, and total costs of care in 2013. The statistically significant difference started at a CS score of 3 and increased steadily to a CS score of 40 or higher in all models. Members with a CS score of 40 or higher had 4 times higher odds of hospitalization in 2013 (odds ratio [OR] = 4.4, 95% confidence interval [CI] = 2.78-6.89); 5 times higher odds of ER visits in 2013 (OR=5.32, 95% CI=3.27-8.97); and 3 times higher odds of higher total health care costs (OR=3.2, 95% CI=2.52-4.15). The c-statistics

showed good concordance with CS score and outcomes of hospitalization (c-statistic 0.720) and ER visits (c-statistic 0.680).

Table 4 shows the results of fitting a trend line to the adjusted model results to generate a linear regression equation (e.g., $y = mx + b$) where coefficient m indicates that for every additional 1-point change in CS score, costs or events can be expected to change by an average of m. We found that a 1-point change in CS score was associated with the following: (a) \$1,488 change in total cost of care; (b) 0.9% change in the

FIGURE 2 Distribution of Unadjusted Total Cost of Care in 2013 by Controlled Substance Score

Note: Members were placed into 1 of 23 CS score ranges according to their 4Q 2012 CS scores. A member's 2013 total cost of care was determined by summing all medical and pharmacy claims allowable amounts during 2013. The lower bar graph represents the number of members in each CS score range. CS=controlled substance.

hospitalization rate; and (c) 1.5% change in the ER visit rate with an R^2 of 0.96 or greater.

Discussion

In a time of national attention to the increasing risk associated with CS overuse and abuse, the results of this study provide useful evidence regarding the association between an individual's CS use and health care consumption. This study validates, in a large commercially insured U.S. cohort, a linear association between increasing CS use, characterized by CS scores, with poorer health outcomes (i.e., higher rates of hospitalizations and ER visits) and higher health care costs. For each 1-point CS score change, total cost of care changed \$1,488; all-cause hospitalizations changed 0.9%; and ER visits changed 1.5%. Previous published research of a prescriber letter campaign targeted at CS prescribers of individuals with

a CS score greater than 12 demonstrated an additional incremental 1.36 points reduction in CS score, compared with a concurrent control group.¹⁰ By combining those results with the current findings and applying them to a model population of 10,000, we can expect to find 20 members (0.2%) with a CS score of 12 or more. The potential savings associated with the 1.36 CS score reduction can be calculated as savings (1.36 points $\times$ \$1,488 = \$2,024) multiplied by 20 members equals \$40,480, which equates to \$0.34 per member per month potential cost avoidance. (i.e., dividing \$40,480 by 10,000 $\times$ 12 [1 year]). In addition, study results suggest a potential hospitalization reduction of 0.9% and ER visit reduction of 1.5%.

This study's findings are consistent with a body of evidence demonstrating the relationship between opioid abuse and increased health care resource utilization, including cost. In a recent analysis examining health care use and substance abuse

TABLE 3 Multivariate Modeling Results: Controlled Substance Score Association with Health Care Use and Costs in 1-Year Follow-up

Characteristic	Hospitalizations in 2013 OR (95% CI)	ER Visits in 2013 OR (95% CI)	Total Health Care Cost in 2013 OR (95% CI)	Characteristic	Hospitalizations in 2013 OR (95% CI)	ER Visits in 2013 OR (95% CI)	Total Health Care Cost in 2013 OR (95% CI)
CS score, 4Q 2012				Proportion with bachelor degrees in member ZIP code			
2.5	1.00 (reference)	1.00 (reference)	1.00 (reference)	< 17%	1.00 (reference)	1.00 (reference)	1.00 (reference)
3 to <4	1.04 (1.02-1.07) ^a	1.05 (1.03-1.07) ^a	1.09 (1.08-1.09) ^a	17% to 24%	0.95 (0.93-0.97) ^a	0.95 (0.94-0.97) ^a	0.99 (0.98-0.99) ^a
4 to <5	1.12 (1.09-1.15) ^a	1.11 (1.09-1.13) ^a	1.10 (1.09-1.11) ^a	25% to 39%	0.92 (0.90-0.95) ^a	0.87 (0.86-0.89) ^a	0.98 (0.97-0.99) ^a
5 to <6	1.17 (1.14-1.21) ^a	1.14 (1.12-1.16) ^a	1.16 (1.15-1.17) ^a	40%+	0.84 (0.81-0.86) ^a	0.80 (0.78-0.82) ^a	0.96 (0.95-0.97) ^a
6 to <7	1.19 (1.15-1.23) ^a	1.16 (1.13-1.19) ^a	1.16 (1.15-1.18) ^a	Median household income in member ZIP code			
7 to <8	1.30 (1.26-1.35) ^a	1.25 (1.21-1.28) ^a	1.25 (1.24-1.27) ^a	< \$43,000	1.00 (reference)	1.00 (reference)	1.00 (reference)
8 to <9	1.38 (1.32-1.44) ^a	1.35 (1.31-1.39) ^a	1.29 (1.27-1.31) ^a	\$43,000 to \$55,000	1.00 (0.98-1.02)	0.94 (0.92-0.95) ^a	1.04 (1.03-1.05) ^a
9 to <10	1.48 (1.41-1.56) ^a	1.38 (1.33-1.44) ^a	1.36 (1.33-1.39) ^a	\$55,000 to \$70,000	0.98 (0.95-1.00)	0.89 (0.88-0.91) ^a	1.06 (1.05-1.07) ^a
10 to <11	1.52 (1.43-1.61) ^a	1.46 (1.40-1.53) ^a	1.37 (1.34-1.40) ^a	\$70,000+	0.97 (0.94-1.00)	0.92 (0.90-0.94) ^a	1.14 (1.13-1.15) ^a
11 to <12	1.70 (1.59-1.81) ^a	1.57 (1.49-1.66) ^a	1.49 (1.45-1.54) ^a	Pharmacy Risk Group Scores in 2012			
12 to <13	1.68 (1.55-1.82) ^a	1.57 (1.48-1.68) ^a	1.46 (1.41-1.51) ^a	0 to <1.2	1.00 (reference)	1.00 (reference)	1.00 (reference)
13 to <14	1.63 (1.49-1.78) ^a	1.66 (1.55-1.79) ^a	1.42 (1.37-1.48) ^a	1.2 to <2	1.33 (1.29-1.37) ^a	1.18 (1.16-1.20) ^a	1.22 (1.22-1.23) ^a
14 to <15	1.98 (1.79-2.18) ^a	1.93 (1.78-2.09) ^a	1.55 (1.48-1.62) ^a	2 to <3.3	1.59 (1.54-1.64) ^a	1.35 (1.33-1.38) ^a	1.42 (1.41-1.44) ^a
15 to <16	1.79 (1.59-2.01) ^a	1.88 (1.72-2.07) ^a	1.49 (1.42-1.57) ^a	3.3+	2.18 (2.11-2.25) ^a	1.73 (1.70-1.77) ^a	1.94 (1.92-1.95) ^a
16 to <17	1.74 (1.52-1.97) ^a	1.90 (1.71-2.10) ^a	1.64 (1.55-1.73) ^a	Charlson Comorbidity Index Scores in 2012			
17 to <18	2.06 (1.78-2.36) ^a	1.88 (1.67-2.12) ^a	1.59 (1.49-1.69) ^a	0	1.00 (reference)	1.00 (reference)	1.00 (reference)
18 to <19	2.04 (1.74-2.38) ^a	2.01 (1.76-2.30) ^a	1.71 (1.59-1.85) ^a	1	1.25 (1.22-1.28) ^a	1.27 (1.25-1.29) ^a	1.19 (1.18-1.20) ^a
19 to <20	2.00 (1.66-2.39) ^a	2.06 (1.77-2.39) ^a	1.72 (1.59-1.87) ^a	2	1.60 (1.55-1.64) ^a	1.32 (1.29-1.35) ^a	1.84 (1.82-1.86) ^a
20 to <21	2.30 (1.89-2.79) ^a	2.36 (1.99-2.80) ^a	1.81 (1.65-1.99) ^a	3+	2.34 (2.26-2.42) ^a	1.79 (1.74-1.85) ^a	3.06 (3.01-3.11) ^a
21 to <25	2.53 (2.23-2.87) ^a	2.63 (2.35-2.94) ^a	1.96 (1.84-2.09) ^a	Total cost of care (pharmacy and medical costs in 2012)			
25 to <30	2.50 (2.08-3.00) ^a	2.85 (2.42-3.35) ^a	1.94 (1.77-2.12) ^a	\$0 to <\$1,600	1.00 (reference)	1.00 (reference)	1.00 (reference)
30 to <40	2.98 (2.29-3.85) ^a	3.69 (2.89-4.74) ^a	2.15 (1.88-2.46) ^a	\$1,600 to \$4,500	1.33 (1.29-1.38) ^a	1.14 (1.12-1.16) ^a	1.54 (1.53-1.55) ^a
40+	4.40 (2.78-6.89) ^a	5.32 (3.27-8.97) ^a	3.20 (2.52-4.15) ^a	\$4,500 to \$11,000	1.60 (1.55-1.65) ^a	1.24 (1.22-1.27) ^a	2.11 (2.10-2.13) ^a
Age, years				\$11,000+	1.94 (1.88-2.01) ^a	1.38 (1.36-1.41) ^a	3.71 (3.68-3.75) ^a
18 to <34	1.00 (reference)	1.00 (reference)	1.00 (reference)	ER visits in 2012			
34 to 46	0.81 (0.79-0.83) ^a	0.80 (0.79-0.81) ^a	1.12 (1.12-1.13) ^a	No	1.00 (reference)	1.00 (reference)	1.00 (reference)
47 to 56	0.86 (0.84-0.89) ^a	0.66 (0.65-0.67) ^a	1.26 (1.25-1.27) ^a	Yes	1.50 (1.47-1.53) ^a	2.51 (2.48-2.54) ^a	1.08 (1.08-1.09) ^a
57+	1.12 (1.09-1.15) ^a	0.63 (0.62-0.64) ^a	1.37 (1.35-1.38) ^a	Hospitalizations in 2012			
Female	1.00 (reference)	1.00 (reference)	1.00 (reference)	No	1.00 (reference)	1.00 (reference)	1.00 (reference)
Male	0.92 (0.91-0.94) ^a	0.90 (0.89-0.91) ^a	1.00 (0.99-1.00)	Yes	1.73 (1.69-1.77) ^a	1.03 (1.01-1.05)	0.94 (0.93-0.95) ^a
Proportion of whites in member ZIP code				Region			
<74%	1.00 (reference)	1.00 (reference)	1.00 (reference)	South	1.00 (reference)	1.00 (reference)	1.00 (reference)
74% to 85%	1.03 (1.00-1.05)	0.99 (0.97-1.00)	0.99 (0.98-0.99) ^a	Midwest	1.00 (0.98-1.02)	0.99 (0.98-1.00)	1.25 (1.25-1.26) ^a
86% to 92%	1.01 (0.99-1.04)	0.97 (0.96-0.99) ^a	0.97 (0.96-0.98) ^a				
93%+	1.02 (1.00-1.05)	1.01 (0.99-1.02)	0.94 (0.93-0.94) ^a				

Note: Model fit c-statistic 0.720148 for hospitalizations and 0.680014 for ER visits.

^aP<0.001.

CI=confidence interval; CS=controlled substance; ER=emergency room; OR=odds ratio; 4Q=fourth quarter.

among 5 years of data from the National Survey on Drug Use and Health, people reporting a substance use disorder related to nonmedical use of illicit and prescribed CS drugs (e.g., street drugs, opioids, stimulants, and sedatives) had increased hospitalization rates compared with abstainers.²⁰ The hospital costs followed similar trends, with increased cost for those using illicit drugs, annual per person, of \$2,783, compared with alcohol (\$1,122) and marijuana (\$1,057). Xie et al. (2014)

examined health care resource utilization using MarketScan Commercial Claims and Encounters, Medicare Supplemental, and Hospital Drug databases between 2006 and 2010.²¹ Opioid users had significantly higher total health care costs compared with nonusers (\$49,766 vs. \$19,875, $P<0.0001$). Opioid users also had significantly higher inpatient visits, office visits, and ER visits.²¹ Finally, Aetna administrative databases were used to identify subjects with at least 2 paid claims for scheduled

TABLE 4 Adjusted Model Trend Line Equations and Interpretation

CS Score Association	Adjusted Trend Line Equation	R ²	Meaning of 1-point Change in CS Score
Hospitalizations	$Y = 0.9021x + 4.3809$	0.9668	0.9% higher rate of hospitalizations for every 1 point
ER visits	$Y = 1.524x + 13.106$	0.9771	1.5% higher rate of ER visits for every 1 point
Total health care cost	$Y = 1488x + 8311.1$	0.9823	\$1,488 higher total health care cost for every 1 point

CS=controlled substance; ER=emergency room.

II or III drugs between 2009 and 2012, and it was found that higher opioid doses were associated with increased risk of hospitalizations and longer stays.²²

Although the CS score algorithm used in this study has not been directly correlated with documented “prescription drug abuse,” the algorithm aims to identify a similar issue. The risk of prescription drug dependence is increased when drugs are combined with other similar agents or central nervous system-acting drugs.² The risk can also be increased as more drugs are used over time. In addition, there is an association between “pharmacy shopping” among those identified at risk of abusing prescription drugs.²³ The components of the CS score algorithm include all of these risks: increasing frequency of use, doctor and pharmacy shopping, and volume. The CS score algorithm also includes all CS, not just opioids.

Using a CS score algorithm is only one way to identify members for intervention. All parties in the health care system need to be involved in order to have an effect on member safety and outcomes. For example, prescribers can use information in their state Prescription Drug Monitoring Program (PDMP) to augment information shared by a health insurer or pharmacy benefit manager.²⁴ States can also choose to allow access to the PDMP by third-party payers for improved information sharing and surveillance.⁹ In addition, some states require prescribers to review the PDMP before writing a prescription for CS.^{9,25,26} Other methods of identifying members for intervention include examination of potential doctor or pharmacy shopping behaviors, history of substance abuse disorders, and possibly concomitant use of opioids with buprenorphine-containing products used to treat opioid addiction.

Limitations

It is worth noting the limitations of this analysis. First, this study examined the association between a CS score in 4Q 2012 and health care use in 2013. The CS score trends in 2013 were not evaluated. Hence, a direct cause and effect link

cannot be made. Second, pharmacy claims data include assumptions of members’ drug use and medication-taking behaviors. Cash-paid CS prescriptions generally are not submitted to the pharmacy benefit manager so would not be included in members’ CS scores. Third, data used in this study were limited to commercial populations, primarily in the central and southern regions of the United States so may not be generalizable to Medicare and Medicaid individuals. However, this study may be a more nationally representative sample and adds to the body of evidence in other populations. Fourth, the CS score algorithm has not been correlated to hospitalizations or ER visits associated with CS abuse or misuse, such as opioid overdose. Fifth, although this analysis adjusted for the 10-year risk of mortality using the Charlson Comorbidity Index and the Optum Pharmacy Risk Group score as a proxy for severity of illness, the study is subject to unmeasured confounding potentially influencing the results. For example, these indices may not capture all medical conditions (e.g., psychiatric conditions) found to be associated with CS abuse/misuse and negative health outcomes. Furthermore, the use of medical claims in addition to pharmacy claims for identifying members may enhance or more accurately identify members (e.g., exclude members with cancer). Finally, CS misuse may lead to lower adherence with other treatment regimens and ultimately higher health care resource use.²⁰ Despite these limitations, this study used recent data from a large claims database, which is critical for evaluation of the increasing problem of prescription drug misuse.

Conclusions

Abuse and overdose of CS, and in particular opioids, are an epidemic in the United States. The findings in this analysis build on previous research showing decreased CS use following prescriber mailings by validating the relationship between a CS score algorithm and effect on negative health outcomes, including hospitalizations and costs. Collaboration between health insurers, pharmacy benefit managers, prescribers, and other parties is needed to address prescription CS abuse in order to improve member safety. A CS scoring algorithm and retrospective DUR program using a prescriber mailing is just one way to make a difference. Health insurers should continue to develop and improve their clinical programs aimed at CS prescription drug misuse. Further research must continue to evaluate predictive ways to identify CS prescription drug abuse and overdose before it occurs.

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