Preventable hospitalizations among adult Medicaid beneficiaries with concurrent substance use disorders

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Abstract

Objective. We aim to examine the relationships between substance use disorders and preventable hospitalizations for Ambulatory Care Sensitive Conditions among adult Medicaid beneficiaries.

Methods. Cross-sectional analysis using de-identified Medicaid claims data in 2012 from 177,568 beneficiaries in Missouri was conducted. Logistic regression models were estimated for the associations of substance use disorder status with Ambulatory Care Sensitive Conditions, demographics, chronic physical and mental illnesses. Zero-inflated negative binomial regressions assessed substance use disorders, hospitalization for Ambulatory Care Sensitive Conditions, and length of hospital stay for Ambulatory Care Sensitive Conditions adjusting for co-morbid physical illnesses, mental illnesses and demographics.

Results. Over 12% of the sample had been diagnosed for substance use disorder. Beneficiaries with substance use disorder were more likely than Nonsubstance use disorder beneficiaries to have admissions for chronic conditions including short/long-term complications of diabetes, uncontrolled diabetes, hypertension, chronic obstructive pulmonary disease/asthma, but not for acute conditions. While substance use disorder beneficiaries were more likely than Nonsubstance use disorder beneficiaries to be hospitalized for any Ambulatory Care Sensitive Conditions; there were no statistical differences between the two groups in terms of length of hospital stays.

Conclusions. Substance use disorder is statistically associated with hospitalizations for most Ambulatory Care Sensitive Conditions but not with length of hospital stay for Ambulatory Care Sensitive Conditions, after adjusting for covariates. The significant associations between substance use disorder and Ambulatory Care Sensitive Condition admissions suggest unmet primary health care needs for substance use disorder beneficiaries and a need for integrated primary/behavioral healthcare.

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Introduction

Drug users often face multiple, concurrent physical and mental health problems (Morgenstern et al., 2008; Lysney and Strang, 2013; Degenhardt and Hall, 2012; Degenhardt et al., 2013). Although drug users are more in need of health care services because of poor general health compared with the general population, they are less likely to receive the same quality of health care as their non-drug use counterparts (Deehan et al., 1998a,b,c; Ahern et al., 2007). Several contributory factors have been identified for this disparity in health care services between drug-users and non-users, including poor treatment compliance (Brener et al., 2010; Cohen et al., 2004), inability to access desired assistance (Druss and von Esenwein, 2006; Santos et al., 2013; McCoy et al., 2001), stigmatization of drug users by medical personnel at health care facilities (Neale et al., 2007, 2008; Henderson et al., 2008), and disadvantaged socioeconomic status (Rice, 1991; McBride et al., 2005). Consequently, drug users may not have adequate access to proper care when they get sick. Even when proper care is accessible, they may still be reluctant to seek professional treatments because of negative experiences from past services. The delay of proper and timely treatment could therefore lead to deterioration of an existing illness which in turn may result in hospital admissions.

Research indicated that hospitalizations for certain health conditions such as complications of diabetes, hypertension, chronic obstructive pulmonary disease (COPD), asthma, and some other problems are potentially preventable if proper and timely care is provided (Ansari et al., 2006; Agency for Healthcare Research and Quality, 2014; Bindman et al., 1995). Because admissions for these health problems,
also termed as Ambulatory Care Sensitive Conditions (ACSCs), are considered preventable, rates of ACSC hospitalization are frequently used as the indicator of outpatient services and the measure of access to primary care (Bindman et al., 1995; Basu et al., 2014). Apparently, both patients and the health care system may greatly benefit from reducing hospitalizations for ACSCs. However, there is a gap in the research literature when it comes to understanding the relationships between substance use disorders (SUDs) and admission for ACSCs.

While many studies have shown that SUD is associated with preventable conditions/ACSCs (Sumino et al., 2014; Sumino and Cabana, 2013; Caponnetto et al., 2013; Clark et al., 2009; Gore et al., 2010; Maruyama et al., 2013; Coffey et al., 2012), the relationships between ACSC admissions and substance use/dependency are relatively under-explored. In a systematic qualitative review of studies on preventable hospitalization in chronic diseases, Muenchberger and Kendall found that over one-third of the reviewed studies focused on health status, socioeconomic status, or general demographics, whereas substance abuse/dependency was examined by less than 5% (Muenchberger and Kendall, 2010). Several recent studies have indirectly explored these issues; however, they focused mainly on other specific populations, such as patients with co-occurring mood disorders (Daratha et al., 2012), veterans (Gao et al., 2014; Yoon et al., 2012), or patients with a specific medical diagnosis such as diabetes (Leung et al., 2011; Druss et al., 2012), where substance users were treated as a sub-group in these studies.

In the US, it is estimated that 13% of adult Medicaid beneficiaries have been diagnosed for substance use disorders within a 12-month time period (Busch et al., 2013), totaling over three million people in 2011 (Kaiser Family Foundation, 2014; United State Census Bureau, 2011). Medicaid expansion in the United States has been implemented in all states in 2014 (Centers for Medicare and Medicaid Services, 2011). If Medicaid beneficiaries in Missouri who had a concurrent SUD in 2012 were approved by the Institutional Review Board at the University of Missouri — St. Louis and by MoHealthNet.

### Study sample

In 2012, nearly a million (n = 987,163) people were enrolled in the Missouri Medicaid program. We excluded those who were younger than 18 years old (n = 540,068) and/or having a total of more than 30 days without Medicaid coverage (n = 132,570). Due to the potentially incomplete claims data for those who were also enrolled in Medicare, an additional 136,957 people who were both Medicaid and Medicare dually eligible (duals) were excluded. After further excluding cases with missing data, there were 177,568 adult Medicaid beneficiaries in the final sample.

### Measures

In the data extract, each claim was associated with up to five ICD-9-CM diagnoses. A positive diagnosis (yes/no) for a target disorder was identified if any of the five ICD-9-CM codes in the claims data met the code set for the target disorders during the reporting period. To determine SUDs, ICD-9-CM codes for dependence on or abuse of alcohol, opiates, sedatives, cocaine, cannabis, amphetamine, hallucinogens, and other substances were examined (2910–2929, 30300–3059). Beneficiaries were identified as ‘SUD’ cases if they were diagnosed for any of these SUDs in the 12-month time period and otherwise labeled as ‘NonSUD’. For ACSC admissions, a list of thirteen Prevention Quality Indicators (PQIs) developed by the Agency for Healthcare Research and Quality (AHRQ) were used to identify ACSC admissions, which include diabetes, COPD/asthma, hypertension, heart failure, angina, appendicitis, dehydration, bacterial pneumonia, and urinary tract infection (URI), (AHRQ, 2014). Nine of them were grouped together to form the chronic conditions (see Table 3). The principal diagnosis for an episode of hospitalization was determined by the first discharge diagnosis in the claims data. Additionally, we examined the total number of inpatient days related to any ACSCs and chronic ACSCs.

### Statistical analysis

Bivariate associations between SUD status and categorical demographic variables; SUD and illnesses (ACSCs with physical and mental illnesses) were examined using odds ratios and chi-square tests. Crude odds ratios (ORs), adjusted odds ratios (aORs) and 95% confidence interval (95% CI) for the associations between admissions for individual ACSCs and SUD were estimated using logistic regression models. Furthermore, zero-inflated negative binomial regression (ZINB) was used to estimate the relationship of SUD, with the length of hospital stay regarding ACSCs and chronic ACSCs. Zero-inflated negative binomial regression is suitable for modeling data with overdispersed count variables and excessive structured zeros commonly observed in insurance, biomedical, and health science studies (Ismail and Zamani, 2013; Phang and Loh, 2013). For multivariate analyses, co-morbid chronic physical illnesses, mental illnesses, and socio-demographic variables such as age group, gender, race/ethnicity, and residential location were used for statistical adjustments. Specific chronic physical illnesses included heart failure, hypertension, diabetes, COPD/asthma, and an overall comorbidity measure defined as the total number of physical illnesses (n = 26) in the claims data (Elixhauser et al., 1998). Mental illnesses included schizophrenia (295xx); bipolar disorder (2960); other mental illnesses such as major depression, episodic mood disorders, anxiety, dissociative and somatoform disorders, acute reaction to stress, and other nonpsychotic mental illnesses (2962x, 2963x, 2969–2988, 300xx, 301–3026, 3071, 30751–30753, 3083–3149); and pervasive developmental disorders/intellectual disabilities (29900–2998, 317xx–319xx). Codes for mental illnesses were based on the code sets used by the Missouri Department of Mental Health to identify clients for the statewide Health Care Home Initiative. Regression analyses on ACSC admissions and length of hospitalizations were conducted among cases with the corresponding diagnoses. For example, admissions for uncontrolled diabetes were analyzed for those who have diabetes. We used a 4-category variable (metropolitan, micropolitan, small town, and rural) based on beneficiaries’ residential zip codes to define residential location (Rural Health Research Center, 2014). All statistical tests were two-sided, with alpha = 0.05. SAS statistical software, version 9.3 (SAS Institute Inc., Cary, NC) was used for all statistical analyses and the GENMOD procedure for the two-part modeling.
Results

Beneficiaries’ characteristics

A total of 177,568 non-dual adult Medicaid beneficiaries were included in the analysis. Table 1 presents beneficiaries’ characteristics and the prevalence of mental/physical illnesses. The majority of the sample was female (72%), Caucasian (69%), younger than 40 years old (63%), and living in metropolitan areas (61%). Over 12% of the sample have been diagnosed for SUD (n = 21,661, Table 1). All older-age groups except the oldest group were more likely to have SUD compared with the youngest-age group (Table 1). Caucasians were more likely to have SUD compared with African American and ‘other race’. Furthermore, males were more likely than females to have SUD, and beneficiaries living in metropolitan also have significantly higher odds of having SUD compared with those living in other areas.

For comorbid physical and mental illnesses, SUD beneficiaries were more likely than NonSUD beneficiaries to have a diagnosis for hypertension and COPD/asthma, bipolar disorders, major depression, schizophrenia, and non-psychotic mental illnesses. SUD beneficiaries also have a higher overall comorbidity burden as indicated by more comorbid physical illnesses (Wilcoxon test, p < 0.0001).

For beneficiaries with SUD, the most common SUDs were dependence on/abuse of alcohol, cannabis, opiates, and amphetamines. Multiple SUD was common — excluding nicotine, 36% of the SUD beneficiaries were diagnosed for dependence on/abuse of two or more classes of substances (Table 2).

Table 1

| Age group | n  | % of SUD | Crude OR | 95% CI  |
|-----------|----|----------|----------|---------|
| 18-29     | 6084 | 8.12 | 1 | Referent |
| 30-39     | 5255 | 14.14 | 1.79 | 0.86-0.94 |
| 40-49     | 4933 | 18.37 | 2.44 | 1.92-2.86 |
| 50-59     | 4516 | 16.82 | 2.19 | 1.79-2.65 |
| 60+       | 873  | 7.40  | 0.84 | 0.94-0.79 |

Race/ethnicity

| Gender | n  | % of SUD | Crude OR | 95% CI  |
|--------|----|----------|----------|---------|
| Female | 12579 | 9.78 | 1 | Referent |
| Male   | 9085  | 18.56 | 1 | Referent |

Residential location

| Chronic physical illnesses | n  | % of SUD | Crude OR | 95% CI  |
|---------------------------|----|----------|----------|---------|
| Hypertension              | 5787 | 18.21 | 1 | Referent |
| COPD/asthma               | 8734 | 12.89 | 1 | Referent |
| Diabetes                  | 1272 | 12.54 | 1 | Referent |
| Heart failure             | 729  | 17.08 | 1 | Referent |

Mental illnesses

| Mental illnesses | n  | % of SUD | Crude OR | 95% CI  |
|------------------|----|----------|----------|---------|
| Bipolar disorders| 6990 | 34.68 | 1 | Referent |
| Major depression | 6756 | 31.60 | 1 | Referent |
| Developmental/intellectual disorders | 313 | 5.24 | 1 | Referent |
| Schizophrenia    | 3329 | 33.78 | 1 | Referent |
| Other mental disorders | 15472 | 22.60 | 1 | Referent |

Overall comorbidity [mean (SD)]

| SUD | NonSUD |
|-----|--------|
| 2.04 | 1.24 |

SUD and hospital admissions for ACSCs

Multivariate logistic regressions were estimated for the associations of SUD with different ACSC admissions, adjusting for covariates. Due to the low prevalence, perforated appendix, angina without procedure, and lower-extremity amputation were not submitted to the multivariate analysis. After taking into account the effects of other covariates, there were significant associations between SUD and hospital admissions due to diabetes with short/long-term complications, uncontrolled diabetes, hypertension, and COPD (Table 3). None of the admissions for acute ACSCs were statistically associated with SUD. Although SUD was statistically associated with admissions for URI in the univariate analyzes, the significant association diminished after adjusting for other covariates.

SUD and length of hospital stay

The zero-inflated negative binomial regressions were estimated for the relationships between SUD and length of hospital stay due to any ACSCs or chronic ACSCs. After adjusting for covariates, the zero-inflated parts of the ZINB regressions showed that SUD beneficiaries were more likely than NonSUD beneficiaries to have admissions for any ACSCs or chronic ACSCs (Tables 4 & 5). Analysis of the count values showed that SUD was not statistically associated with length of hospital stay for any ACSCs or chronic ACSCs. The findings from the ZINB regressions suggest that, when both SUD and NonSUD beneficiaries went to seek help because of their physical illnesses, SUD beneficiaries were more likely than NonSUD beneficiaries to be admitted for ACSCs. Furthermore, because of the relatively large sample size, the non-significant associations between SUD and length of hospital stay clearly suggest that once SUD beneficiaries were admitted for any ACSCs or chronic ACSCs, their length of hospital stay did not differ significantly from that of their NonSUD counterparts.

Discussions

The findings indicated that SUD beneficiaries not only had higher likelihood of having hypertension, COPD/asthma, bipolar disorders, schizophrenia, major depression, non-psychotic mental illnesses, and a higher overall comorbidity burden compared to beneficiaries without SUDs, they were also more likely to have hospital admissions for most of the ACSCs, as well as the chronic ACSC cluster, even after adjusting for covariates such as age, gender, ethnicity, residential area, and comorbid physical and mental illnesses. As mentioned, a possible reason for
admission for ACSCs is the delay of proper care (Bindman et al., 1995; Ansari et al., 2006; AHRQ, 2014). Because availability and accessibility of primary care services for ACSCs should not differ between these two populations under the current policy on Medicaid coverage, the elevated risk of ACSC admissions among SUD beneficiaries should be less affected by access of care, but rather that they are hesitant to seek help or being treated differently. Substance users may experience stigmatization from medical personnel at primary care facilities, such as a medical physician's tendency to provide inferior services (Deehan et al., 1998a,b, 1998c; Ahern et al., 2007). Consequently, those who have negative experiences about their primary care providers may hesitate to seek help until their health problem becomes more serious. Alternatively, substance users may prefer outpatient facilities such as community mental health centers (CMHCs) as their principal point of service, or be treated differently. Substance users may experience negative social influences and experiences, which may prevent them from seeking help. In addition, substance users may have negative experiences about their primary care providers or be treated differently in terms of the quality of care they receive. This may lead to a delay in seeking help and a decrease in the likelihood of hospitalization for ACSCs.

### Table 3

| PQI# ACSC                  | SUD       |  | NonSUD    |  | Total   | Crude OR | 95% CI    | aORb   | 95% CI   |
|----------------------------|-----------|---|-----------|---|---------|----------|-----------|--------|----------|
| n | % | n | % | n | % |  |  |  |  |
| 1 Diabetes short-term complications | 105 | 8.25 | 251 | 2.75 | 356 | 3.43 | 3.18 | 2.51–4.02 | 2.50 | 1.35–2.68 |
| 2 Diabetes long-term complications | 109 | 8.57 | 313 | 3.43 | 422 | 4.06 | 2.64 | 2.10–3.31 | 1.59 | 1.22–2.01 |
| 3 Uncontrolled diabetes | 35 | 2.75 | 92 | 1.01 | 127 | 1.22 | 2.78 | 1.87–4.11 | 1.79 | 1.15–2.77 |
| 4 Lower-extremity amputation among patients with diabetes | 5 | 0.39 | 29 | 0.32 | 34 | 0.33 | 1.24 | 0.48–3.20 |        | –         |
| 5 COPD or asthma in older adults | 285 | 9.04 | 804 | 6.32 | 1089 | 8.86 | 1.47 | 1.28–1.70 | 1.22 | 1.04–1.43 |
| 6 Asthma in younger adults | 32 | 1.69 | 119 | 2.02 | 151 | 2.14 | 1.34 | 0.90–1.99 | 0.98 | 0.63–1.54 |
| 7 Hypertension | 63 | 1.09 | 158 | 0.61 | 221 | 0.70 | 1.80 | 1.34–2.41 | 1.47 | 1.05–2.03 |
| 8 Heart failure | 105 | 14.40 | 445 | 12.58 | 550 | 12.89 | 1.17 | 0.93–1.47 | 0.90 | 0.70–1.17 |
| 9 Angina without surgery | 9 | 3.07 | 30 | 2.39 | 39 | 2.52 | 1.29 | 0.61–2.75 |        | –         |
| 10 Perforated appendix | 6 | 37.50 | 35 | 41.18 | 41 | 40.59 | 0.86 | 0.29–2.58 |        | –         |
| 11 Dehydration | 56 | 7.12 | 164 | 6.96 | 220 | 7.00 | 1.03 | 0.75–1.41 | 0.94 | 0.66–1.34 |
| 12 Bacterial pneumonia | 210 | 19.74 | 659 | 17.77 | 869 | 18.21 | 1.14 | 0.96–1.35 | 1.03 | 0.85–1.25 |
| 13 Urinary tract infection | 101 | 3.79 | 360 | 2.39 | 461 | 2.60 | 1.61 | 1.29–2.02 | 1.16 | 0.90–1.50 |

a ACSC admission rates were computed for the corresponding diagnosis. For instance, the number of SUD cases with diabetes, n = 1272 (see Table 1), was used as the denominator and the number of non-SUD cases with diabetes, n = 2512, was used as the non-SUD denominator.
b aORs obtained from multivariate logistic regressions were adjusted for gender, age, race/ethnicity, residential location, SMI, non-psychotic mental illnesses, developmental disorders, nicotine use disorders, chronic medical diagnoses (COPD/asthma, heart failure, hypertension, and diabetes), and the overall claim based comorbidity.

### Table 4

| Covariates       | Part 1: binary modela |  | Part 2: negative binomial modelb |  |
|------------------|-----------------------|---|---------------------------------|---|
|                  | Est. | aOR | 95% CI             | Est. | SE | 95% CI |
| Intercept        | –4.86 | 0.01 | 0.00–0.01 | 0.87 | 0.09 | 0.71–1.04 |
| Non-SUD Referent | –     | –    | –                 | –    | –    | –         |
| SUD              | 0.28 | 1.33 | 1.19–1.48 | –0.02 | 0.04 | –0.10–0.06 |
| Age group        | 18–29 | Referent | –                 | –    | –    | –         |
| 30–39            | 0.05 | 1.05 | 0.87–1.27 | 0.02 | 0.08 | –0.13–0.18 |
| 40–49            | 0.001 | 1.00 | 0.84–1.19 | –0.10 | 0.07 | –0.24–0.04 |
| 50–59            | –0.09 | 0.92 | 0.78–1.09 | –0.18 | 0.07 | –0.32–0.05 |
| 60+              | –0.14 | 0.87 | 0.72–1.05 | –0.20 | 0.08 | –0.36–0.05 |
| Gender           | Female | Referent | –                 | –    | –    | –         |
| Male             | 0.07 | 1.08 | 0.98–1.18 | 0.13 | 0.04 | 0.06–0.20 |
| Race/ethnicity   | Caucasian | Referent | –                 | –    | –    | –         |
| African American | 0.42 | 1.53 | 1.38–1.69 | 0.09 | 0.04 | 0.01–0.17 |
| Others           | 0.11 | 1.11 | 0.90–1.37 | –0.03 | 0.09 | –0.20–0.14 |
| Residential location | Metropolitan | Referent | –                 | –    | –    | –         |
| Small town       | –0.12 | 0.88 | 0.77–1.01 | –0.002 | 0.06 | –0.11–0.12 |
| Rural            | –0.22 | 0.80 | 0.69–0.93 | –0.08 | 0.06 | –0.20–0.05 |
| Chronic physical illnesses | Diabetes | 1.01 | 2.73 | 2.48–3.01 | 0.20 | 0.04 | 0.12–0.28 |
|                  | Hypertension | –0.11 | 0.90 | 0.82–0.99 | –0.01 | 0.04 | –0.09–0.07 |
|                  | Heart failure | 1.10 | 3.01 | 2.70–3.35 | 0.12 | 0.04 | 0.04–0.20 |
|                  | COPD/asthma | 0.78 | 2.18 | 1.99–2.40 | 0.04 | 0.04 | 0.04–0.12 |
|                  | Overall comorbidity | 0.26 | 1.30 | 1.27–1.32 | 0.14 | 0.01 | 0.12–0.15 |
|                  | Serious mental illnesses | –0.34 | 0.71 | 0.65–0.79 | 0.002 | 0.04 | 0.08–0.08 |
|                  | Non-psychotic mental illnesses | 0.15 | 1.16 | 1.05–1.28 | 0.17 | 0.04 | 0.09–0.25 |
|                  | Developmental/intellectual mental disorders | –0.75 | 0.47 | 0.32–0.70 | –0.46 | 0.17 | –0.80–0.12 |
|                  | Nicotine use disorders | 0.45 | 1.56 | 1.43–1.71 | 0.09 | 0.04 | 0.12–0.28 |

a Part 1 (zero-inflated part) modeled the likelihood of hospitalization for chronic ACSCs in terms of odds ratios.
b Part 2 modeled the length of hospital stay for chronic ACSCs.
in delay of proper treatment (Druss and von Esenwein, 2006; Miller et al., 2003). More importantly, since the rate of ACSC admission is an indicator of access to high quality primary care, our findings suggest that the disparity in health care services between substance users and non-users also exists among the Medicaid population.

Furthermore, although SUD beneficiaries were more likely to be admitted for ACSCs, there was no statistical difference between SUD and NonSUD beneficiaries in terms of length of hospital stay for ACSCs. Because the length of hospital stay could be an indicator of seriousness of illnesses (Ahern et al., 2007), these results suggested that when SUD beneficiaries got admitted for ACSCs, their conditions might not be more severe than their NonSUD counterparts. These findings are somewhat unexpected. One possible explanation is that, due to the unhealthy life-style, SUD beneficiaries are more susceptible to physical illnesses and hence an increased likelihood of ACSC admissions (Kasl and Cobb, 1966a,b). However, once an individual gets sick, the decision to seek help depends more on the perceived severity of illness and the perceived benefits of treatment, which may not be influenced directly by their SUD status (Mackian et al., 2003, 2004). Future studies which include assessments on patients’ health beliefs and perceptions may help to clarify these issues.

Several limitations should be noted. First, potential changes in the target behavior (i.e., ACSC admissions) in response to policy changes cannot be captured and inferred because of the cross-sectional nature of the study. Second, the generalizability of the findings obtained from a single state (Missouri) in the US to other states and other low income populations is limited. Nevertheless, given the lack of information about preventable hospitalizations among drug users, the present study may serves as the first step towards more comprehensive studies. Third, Medicaid claims data typically do not contain information unrelated to day-to-day administrative operations; it was impossible to examine the relationships between admissions and other endogenous factors such as health belief and perceptions which may impact health behaviors and the risk of ACSC admissions. Fourth, despite the statistically significance, some of the findings have adjusted ORs close to 1.0 with narrow confidence intervals, suggesting that the associations between SUD and ACSCs were relatively weak. Finally, because of a lack of consensus on the set of ACSCs, results obtained in this study may not be comparable with those in other studies, especially when aggregated measures such as the chronic cluster are involved.

**Conclusions**

This study demonstrated that SUD is independently associated with hospitalizations for most of the chronic conditions (5/7), but not with the length of hospital stay due to ACSCs, among adult Medicaid beneficiaries in Missouri. Effects of SUD have been found to contribute independently to ACSC admissions, over and above the effects of other variables, including comorbid mental illnesses. Of particular relevance to policy makers and health care providers is that the significant association between SUD and ACSC admissions implicates the existence of unmet primary health care needs for SUD beneficiaries. These could be the results of inadequate primary care service in the mental health care settings, or inadequate mental health service in primary care settings, or both. In addition to enhancing training for physicians and health care professionals to enable cross-disciplinary services, the integration of primary care and health service in the mental health care settings, or inadequate mental health services may be an alternative solution (Druss and von Esenwein, 2006; National Association of State Mental Health Program Directors, 2005; Schuffman et al., 2009; Woltmann et al., 2012). Further research on the effects of integrated service on preventable hospitalizations among Medicaid SUD beneficiaries or other drug user populations is warranted.

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**Table 5**  
Associations between SUD and hospitalization for any ACSCs, 2012, Missouri, US.

| Covariates                  | Part 1: binary model | 95% CI | Part 2: negative binomial model | 95% CI |
|-----------------------------|----------------------|--------|--------------------------------|--------|
|                             | Est.                 | aOR    | SE                | Est.    | SE    | aOR    |
| Intercept                   | -4.33                | 0.01   | 0.01–0.02         | 0.94    | 0.06  | 0.83–1.05 |
| Non-SUD Referent            | -                   | -      | -                 | -       | -     | -      |
| SUD Referent                | -0.21                | 1.24   | 1.13–1.35         | 0.01    | 0.03  | 0.05–0.08 |
| Age group                   | -                    | -      | -                 | -       | -     | -      |
| 18–29                       | -0.12                | 1.12   | 0.98–1.29         | -0.03   | 0.06  | 0.15–0.08 |
| 30–39                       | 0.05                 | 1.05   | 0.92–1.19         | -0.06   | 0.05  | 0.16–0.05 |
| 50–59                       | 0.04                 | 1.04   | 0.95–1.18         | -0.11   | 0.05  | 0.21–0.01 |
| 60+                         | 0.16                 | 1.17   | 1.02–1.35         | -0.04   | 0.06  | 0.15–0.07 |
| Gender                      | -                    | -      | -                 | -       | -     | -      |
| Female Referent             | 0.001                | 1.00   | 0.93–1.08         | 0.14    | 0.03  | 0.09–0.20 |
| Male Referent               | -                    | -      | -                 | -       | -     | -      |
| Race/ethnicity              | -                    | -      | -                 | -       | -     | -      |
| Caucasian Referent          | 0.17                 | 1.18   | 1.09–1.29         | 0.08    | 0.03  | 0.02–0.15 |
| African American Referent   | 0.06                 | 1.06   | 0.90–1.25         | -0.003  | 0.07  | -0.13–0.13 |
| Others Referent             | -0.26                | 0.77   | 0.68–0.87         | -0.07   | 0.05  | -0.16–0.03 |
| Residential location        | -                    | -      | -                 | -       | -     | -      |
| Metropolitan Referent       | -0.13                | 0.88   | 0.76–0.93         | -0.02   | 0.04  | -0.10–0.07 |
| Micropolitan Referent       | -0.13                | 0.88   | 0.79–0.98         | 0.03    | 0.04  | 0.05–0.11 |
| Small town Referent         | -0.26                | 0.77   | 0.68–0.87         | -0.07   | 0.05  | -0.16–0.03 |
| Rural Referent              | -0.26                | 0.77   | 0.68–0.87         | -0.07   | 0.05  | -0.16–0.03 |
| Chronic physical illnesses  | -                    | -      | -                 | -       | -     | -      |
| Diabetes                    | 0.51                 | 1.67   | 1.54–1.81         | 0.18    | 0.03  | 0.12–2.24 |
| Hypertension                | -0.21                | 0.81   | 0.75–0.88         | -0.05   | 0.03  | -0.11–0.01 |
| Heart failure               | -0.21                | 0.81   | 0.75–0.88         | -0.05   | 0.03  | -0.11–0.01 |
| COPD/asthma                 | 0.74                 | 2.11   | 1.91–2.32         | 0.13    | 0.03  | 0.06–0.19 |
| Overall morbidity           | 0.55                 | 1.73   | 1.61–1.86         | 0.05    | 0.03  | -0.01–0.11 |
| Serious mental illnesses    | 0.33                 | 1.39   | 1.36–1.41         | 0.13    | 0.03  | 0.11–0.14 |
| Non-psychotic mental illnesses | 0.16                | 1.18   | 1.09–1.28         | 0.15    | 0.03  | 0.08–0.21 |
| Developmental/intellectual mental disorders | -0.06 | 0.94 | 0.75–1.18 | -0.05 | 0.09 | -0.24–0.13 |
| Nicotine use disorders      | 0.40                 | 1.48   | 1.38–1.60         | 0.05    | 0.03  | -0.01–0.10 |

a Part 1 (zero-inflated part) modeled the likelihood of hospitalization for any ACSCs in terms of odds ratios.
b Part 2 modeled the length of hospital stay for any ACSCs.
Conflict of interest statement

The authors declare that there are no conflicts of interest.

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