Leveraging big electronic data to identify oral care disparities in individuals with serious mental illness

Vaishali Singhal, DMD, PhD, MS ■ Yuane Jia, PhD ■ Ni Gao, PhD, LCSW ■ Jill York, DDS, MAS
Michal Gold-Rosenbach, DMD ■ Nysa Ginu, MS, BS ■ Rhea Arya, BS ■ Jay Sureshbhai Patel, PhD, MS, BDS

Individuals with serious mental illness (SMI) have poorer oral health than the general population for various reasons, including poor oral hygiene, adverse effects of psychotropic medicines, stigma, fear, cognitive impairment, lack of insurance coverage, and a shortage of professionals qualified to manage the oral health needs of this population. Oral health deteriorates further when care is postponed, resulting in greater treatment needs when the patient visits the dental office. This retrospective study aimed to determine differences in service return rate and frequency of visits for each of 12 American Dental Association (ADA) oral procedures in patients with and without SMI who were treated in a predoctoral dental clinic at a northeastern US dental school. This retrospective study used the dental electronic health records of 12,138 adult patients aged 18 years and over (total of 19,096 unique patient encounters) who received at least 1 comprehensive oral evaluation between January 1, 2017, and August 31, 2021. Three data processing methods were implemented to retrieve periodontal diagnoses in accordance with American Academy of Periodontology guidelines and to extract medical histories and behavioral factors from free text. Chi-square tests determined that there were statistically significant differences between the 2 groups for 4 of 12 ADA procedures, while *t* tests determined that the SMI group had a higher frequency of visits for 6 procedure categories. Logistic regression analysis showed that patients with an SMI had a significantly higher odds ratio of receiving 2 procedure categories (removable prosthodontics and adjunctive general services). A negative binomial regression analysis was then conducted to predict the frequency of visits; patients with an SMI had a higher incidence rate ratio of receiving 4 ADA procedure categories (preventive, removable prosthodontics, oral and maxillofacial surgery, and adjunctive general services). This study identified the existence of oral healthcare disparities in a population with SMI in relation to specific ADA dental procedure categories. Improving integrated care models, interprofessional collaboration, and education of predoctoral dental students and licensed professionals may help alleviate some of the existing disparities.

Received: October 14, 2024
Revised: December 6, 2024
Accepted: March 10, 2025

Keywords: disparities, electronic health records, oral health, serious mental illness

Nearly 20% of Americans (or close to 53 million individuals) over the age of 18 years live with a mental illness. Of these, 14.2 million suffer from serious mental illness (SMI) such as severe anxiety, major depression, bipolar disorder, or schizophrenia spectrum disorders. In 2020, 9.1 million adults in America with a diagnosis of SMI received treatment for their disorder.[1] The fragmented healthcare system framework makes access to care difficult for individuals with SMI.[2] Thus, much of this population does not obtain appropriate mental or general healthcare.[2]

One reason for the underutilization of treatment services may be a gap in Medicaid coverage. Approximately 30% of Medicaid patients risk losing coverage within the first 6 months.[3] Factors such as difficulty with the re-enrollment process, not knowing where to access needed care, inability to obtain an appointment for care, or changes in familial status can lead to a gap in coverage.[3,4] Gaps in coverage can lead to underutilization of services, often resulting in fewer doctor visits and reduced use of needed medications.[3,4] Underutilization of dental services, including preventive services, among the population with SMI is a significant risk factor for caries and tooth loss.[5,6]

Healthcare coverage is essential in the continuum of general healthcare for those with SMI.[3] Between 1997 and 2002, there was a significant increase in the number of adults who did not receive mental healthcare or medications for mental health disorders because cost was a barrier.[4] Approximately 20% of the US population with mental illness is uninsured, compared with 15% of the general population.[4] Additionally, underutilization of healthcare services contributes to delays in receiving needed care and an increase in significant health problems such as diabetes and cardiovascular disease. This population is already at risk for these diseases due to medication use and, often, lifestyle choices.[3,5,7] Furthermore, many persons with SMI leave the workforce, have fewer resources, experience increased isolation from the community, and have a poorer quality of life.[8-10] Thus, the lack of healthcare services has a significant negative impact on this population.[7]

Having insurance does not guarantee the patient will receive the needed healthcare. Access to a mental healthcare provider is a vital component of receiving timely, appropriate, and adequate services. In the United States, on average, there is 1 mental health provider for every 529 patients with mental illness.[11] More than 75% of counties in the United States have a severe shortage of mental health providers, meaning more than 50% of needs remain unmet.[12] Additionally, more than 30% of counties in the United States do not have any outpatient mental healthcare facilities that accept Medicaid.[13,14]

A similar pattern exists regarding Medicaid coverage and utilization of dental services. In a survey of individuals with SMI,

approximately 60% of respondents indicated that they had not seen a dentist in the previous 1-year period.[5] Underutilization of dental services may be due to patients' lack of acceptance of care and treatment, as well as the availability of and access to affordable care.[15] Additional reasons for underutilization of dental services were ambiguity regarding itemized care coverage, out-of-pocket costs, and fear of the dentist.[5]

Individuals with SMI experience poorer oral health than the general population for various reasons.[5,16] Among those with a diagnosis of SMI, such as schizophrenia or bipolar disorder, higher rates of dental decay, untreated caries, and periodontal disease are reported.[5] Oral health deteriorates when care is postponed, resulting in a greater need for extractions when the patient visits the dental office.[5,16,17] Limited training of predoctoral dental students in managing and treating patients with SMI may also be a factor in the greater need for extractions in this population.[18] Additionally, psychotropic medications lead to xerostomia, which patients may attempt to counteract by consuming sugary substances. The combination of increased intake of sugary substances and a diminished salivary flow leads to restoration failure and extensive decay of the dentition.[19]

Another factor in the poor general and oral health of patients with SMI is the fact that some psychotropic medications cause tardive dyskinesia. These uncontrollable and involuntary movements of the body and oral cavity muscles make oral care extremely difficult for both the patient and practitioner.[19] Due to these adverse effects, the patient may not adhere to the medication regimen, resulting in a relapse of the symptoms of the mental health disorder, underutilization of services, failure to attend healthcare visits, poorer overall health outcomes, and poorer quality of life.[19]

A diagnosis of mental illness and resulting tardive dyskinesia is often perceived negatively, even among healthcare providers, leading to stigmatization of patients. The inherently negative stigma can result in discrimination, discriminatory behavior, and labeling.[16,20,21] Stigmatization is exacerbated by power imbalances in healthcare settings.[16] When healthcare providers stigmatize patients, it can delay treatment and worsen oral health.[16] Patients' avoidance of dental care due to stigma increases the incidence of dental decay and oral infections.[15,20,21] Moreover, stigmatized patients may perceive that they receive a lower standard of care and believe that they are often offered tooth extractions rather than restorations.[15]

Dental caries is a common condition that affects oral health and, left untreated, can result in tooth loss. The number of decayed, missing, and filled teeth (DMFT) and the number of decayed, missing, and filled surfaces (DMFS) are indicators of a person's overall oral health. The severity of the individual's oral disease increases as DMFT and DMFS values rise. Those with SMI have a significantly greater number of DMFT and DMFS.[22] The higher indices are due to high numbers of missing and decayed teeth as well as a lower number of filled teeth.[23] Additionally, compared with the general population, those who suffer from SMI have a greater chance of losing all their teeth.[22] Poor oral health and loss of dentition lead to a diet rich in carbohydrates and low in fruit and fiber.[24] A poor diet, a general lack of social support, and an overall sedentary lifestyle increase the risk of metabolic syndrome in this population compared with the general population.[24]

Individuals who experience SMI and substance use disorders have low rates of adherence to treatment.[25] Various factors influence the increased risk of oral disease in people with SMI. These include poor oral hygiene, the side effects of psychiatric medications, stigma, fear, dental anxiety, the cost of dental care, cognitive impairment, lack of transportation, insecure housing status, and the lack of dental professionals qualified to manage the oral health needs of this population.[26,27] Also, those who undergo inpatient treatment and do not receive outpatient follow-up care are at a greater risk of homelessness and rehospitalization for psychiatric care, disrupting the continuity of healthcare services.[28] Better communication between patients and caregivers may improve adherence to care by patients with SMI.[27]

Few studies have compared the disparities in dental care access, service return rates, or rates of DMFT and DMFS between those with SMI and those without SMI. The present study investigated such disparities by reviewing the dental records of 12,138 patients (19,096 unique encounters) who received dental care over the span of 10 years at the predoctoral clinic of a large urban dental school. A single patient could have multiple observations or visits to the clinic, which provides care to underserved populations, and in such cases the details from each visit were included in the analysis. This retrospective study aimed to identify oral health problems and treatment improvement needs in people with SMI. Three research questions guided this analysis:

1. Do mental health issues impact the oral health of a population with SMI compared with a population without SMI?
2. Is the impact of mental health issues on oral health outcomes measured by the frequency of visits and receiving dental treatment after controlling for other factors, such as patient history, demographics, and characteristics?
3. Do other variables, such as patient demographics, insurance status characteristics, and history, impact oral health?

Methods

The institutional review board of Rutgers University approved this study (protocol No. 2022000145).

Patient cohort

Clinical information, such as clinical attachment loss, probing depths, bleeding on probing, and periodontal diagnosis, was retrieved from the dental electronic health records (EHRs) for patients who received at least 1 comprehensive oral examination at a predoctoral dental clinic in a large northeastern US dental school between January 1, 2017, and August 31, 2021. During this period, there were 12,138 patients. To better capture patient history, their complete dental records extending back to 2010 were included. The final analytic sample comprised 19,096 dental records (ie, unique encounters).

Data preprocessing

Since the EHR is intended to support patient care and not research, patients' clinical information may not be readily available in an analyzable format. For a previous and separate research study conducted by a coinvestigator of the present study, 3 data preprocessing methods were developed.[29,30] The same methods were utilized in the present study.

Table 1. Characteristics of the study sample.[a]

Characteristic	Patients, n (%)	
	SMI group	Non-SMI group
Sample size based on number of unique patient encounters		
Total sample	2540 (13.3)	16556 (86.7)
Race based on number of unique patient encounters[b]		
White	836 (58.7)	4093 (48.9)
Black	508 (35.7)	3475 (41.5)
Hispanic	371 (24.2)	3312 (33.5)
Asian	40 (2.8)	563 (6.7)
American Indian	20 (1.4)	143 (1.7)
Native Hawaiian	4 (0.3)	11 (0.1)
Other	1 (0.1)	3 (0.0)
Sex based on number of unique patient encounters		
Male	945 (37.2)	7427 (44.9)
Female	1594 (62.8)	9125 (55.1)
Insurance type based on number of unique patient encounters		
Medicaid/government insurance	1192 (46.9)	10690 (64.6)
Private insurance	66 (2.6)	524 (3.2)
Self-pay/cash	1240 (48.8)	5186 (31.3)
Grant and contract payments	42 (1.7)	156 (0.9)
Medical history based on number of unique patient encounters		
Blood disorders	353 (13.9)	1055 (6.4)
Bone, muscle, or joint disorders	1082 (42.6)	3530 (21.3)
Cardiovascular disease	1072 (42.2)	4594 (27.7)
Endocrine disorders	1097 (43.2)	4939 (29.8)
Gastrointestinal disorders	911 (35.9)	2460 (14.9)
Infectious diseases	277 (10.9)	772 (4.7)
Nervous system disorders	910 (35.8)	1854 (11.2)
Respiratory system disorders	880 (34.6)	2280 (13.8)
Cancer[c]	199 (8.7)	793 (5.4)
Other	1165 (45.9)	5301 (32.0)
Substance use based on number of patients		
Tobacco use	240 (9.4)	954 (5.8)
Alcohol use	523 (20.6)	2726 (16.5)

Groups: SMI, patients with a diagnosis of serious mental illness; Non-SMI, patients without a diagnosis of serious mental illness.

[a]The sample included 12,138 patients with a total of 19,096 unique encounters (dental records).

[b]Race and ethnicity were self-identified by the patients. Data on race were missing for 9307 patients (48.7%), and data on ethnicity were missing for 7685 patients (40.2%).

[c]Data on cancer were missing for 2174 patients (11.4%).

The first preprocessing method was automatic retrieval of periodontal diagnoses from free text. As an example, patients' periodontal diagnoses may not be reported using diagnosis codes, as dentists are reimbursed for procedures performed and not a diagnosis. Thus, the periodontal diagnosis was missing for some patients (32%). Some periodontal diagnoses were available in the clinical notes in a free-text format. Similarly, patients' medical histories and behavior information (such as drinking and smoking) were also available in free text at the time of the study. A natural language processing (NLP) pipeline that followed the 2017 American Academy of Periodontology (AAP) classifications was applied to automatically retrieve and provide periodontal diagnoses from periodontal charting data and clinical notes.[31] As a second method of preprocessing, used for patients without a periodontal diagnosis, an automated decision support system was developed to generate the periodontal diagnosis in accordance with the 2017 AAP classifications. The third preprocessing method employed NLP algorithms to extract patients' medical histories and behavior factors from free text.

Details on the NLP approaches and periodontal diagnosis phenotyping are described in previous work.[21,29,30] The automated approaches to periodontal diagnosis allowed for 99% completeness for periodontal diagnoses.

Study sample

The sample included a diverse group of 12,138 patients, aged 18 years and older, who received at least 1 comprehensive oral examination at the dental clinic of a large northeastern school of dental medicine during the period from 2017 through 2021 (Table 1). The study evaluated a total of 19,096 records for these patients, with encounters dating between 2010 and 2021. Of the participants, 13.3% had an SMI diagnosis, and 86.7% had no SMI diagnosis. Each racial group included patients with SMI as well as patients without SMI. Based on the number of patient encounters, the majority (62.2%) of the patients in the study were receiving Medicaid or government insurance, followed by self-pay (33.7%), private insurance (3.1%), and grants and contract payments (1.0%). Patients with SMI reported a higher amount of tobacco use (9.4%) and alcohol use (20.6%) compared with the non-SMI group (5.8% and 16.5%, respectively).

Measures

The independent variable in the present study was a self-reported diagnosis of a serious mental health condition, including nervous disorders, anxiety disorders, psychiatric illness, and eating disorders. The dependent variables included completing or receiving 1 of 12 oral procedures designated by the American Dental Association (ADA) prior to 2024 and the frequency of visits to complete these procedures.[32] These data were categorized according to the 12 Current Dental Terminology (CDT) codes developed and updated by the ADA: diagnostic, preventive, restorative, endodontics, periodontics, removable prosthodontics, maxillofacial prosthodontics, implant services, fixed prosthodontics, oral and maxillofacial surgery, orthodontics, and adjunctive general services.[32] Other controlled variables included in this study were medical history, substance use, race, sex, and insurance status.

Statistical analysis

The patient records (axiUm, Exan Software) were analyzed for differences between the SMI and non-SMI groups. A comparison was completed to determine differences between the 2 groups in the numbers of visits and dental procedures. Various

medical and demographic factors were utilized as covariates to compare the differences.

Before formal analysis, data screening and assumption checks were conducted. Variables included in the study were those the researchers believed would impact the frequency of visits and receipt of dental treatment for the 12 categories of procedures. A chi-square test was used to explore any disproportional associations between each dental procedure (binary variable) and the presence of SMI. For procedures demonstrating significant associations with mental health conditions, logistic regression was employed to predict the likelihood that patients would undergo each dental procedure while controlling for demographics and medical history.

A *t* test was conducted to assess differences between the SMI and non-SMI groups in the frequency of visits for each procedure. Following the identification of procedures with significant differences in visit frequency between the SMI and non-SMI groups, a Poisson regression (count variable) was conducted. This analysis aimed to predict visit frequency to determine whether mental health conditions significantly influenced the number of visits for each dental procedure when other covariates were considered.

A logistic regression analysis was completed to determine how mental health conditions predict the likelihood of completing or receiving each oral procedure when data are controlled for the demographics and medical history of patients. The final analysis was a negative binomial regression to determine if there was a difference between the 2 groups in the frequency of visits.

Results

A chi-square test was used to explore any disproportional associations between each dental procedure (binary variable) and mental health conditions (SMI group vs non-SMI group). The analysis identified 4 of 12 procedures (preventive, removable prosthodontics, oral and maxillofacial surgery, and adjunctive general services) that showed statistically significant differences between the 2 groups (Table 2). Among the patients who received the removable prosthodontics procedure, 16.3% were identified as having a diagnosis of SMI. Among those who did not receive the removable prosthodontics procedure, 12.0% had a diagnosis of SMI. Among the patients who received adjunctive dental services, 18.0% were identified as having a diagnosis of SMI. Among those who did not receive the adjunctive dental services, 12.1% had a diagnosis of SMI. A similar trend was found for the other 2 procedure categories, preventive and oral maxillofacial surgery.

Insurance analysis

Additional analysis was conducted to evaluate the relationship between each insurance type and how the mental illness condition is related to each procedure type. Among patients with Medicaid insurance, those with a diagnosis of SMI were more likely to receive removable prosthodontics treatment, with 34.1% of the patients in the SMI group receiving such treatment compared with 26.8% of the patients without SMI; this was a statistically significant difference ($P < 0.001$). Furthermore, 38.6% of the self-paying patients with SMI

Table 2. Statistical comparison of procedures undergone by patients in the study groups (12,138 patients with a total of 19,096 encounters).

Procedure[a]	Encounters, n (%)		χ^2
	SMI group	Non-SMI group	
Diagnostic	2540 (13.3)	16556 (86.7)	[b]
Preventive (0)	962 (12.7)	6638 (87.3)	4.50[c]
Preventive (1)	1578 (13.7)	9918 (86.3)	
Restorative (0)	943 (13.5)	6032 (86.5)	0.46
Restorative (1)	1597 (13.2)	10524 (86.8)	
Endodontics (0)	1868 (13.4)	12090 (86.6)	0.30
Endodontics (1)	672 (13.1)	4466 (86.9)	
Periodontics (0)	1576 (13.6)	10024 (86.4)	2.08
Periodontics (1)	964 (12.9)	6532 (87.1)	
Removable prosthodontics (0)	1609 (12.0)	11784 (88.0)	64.46[d]
Removable prosthodontics (1)	931 (16.3)	4772 (83.7)	
Maxillofacial prosthetics (0)	2536 (13.3)	16504 (86.7)	1.85
Maxillofacial prosthetics (1)	4 (7.1)	52 (92.9)	
Implant services (0)	2302 (13.5)	14811 (86.5)	3.24
Implant services (1)	238 (12.0)	1745 (88.0)	
Fixed prosthodontics (0)	2323 (13.4)	15056 (86.6)	0.72
Fixed prosthodontics (1)	217 (12.6)	1500 (87.4)	
Oral and maxillofacial surgery (0)	1072 (11.5)	8232 (88.5)	49.80[d]
Oral and maxillofacial surgery (1)	1468 (15.0)	8324 (85.0)	
Orthodontics (0)	2506 (13.3)	16276 (86.7)	1.69
Orthodontics (1)	34 (10.8)	280 (89.2)	
Adjunctive general services (0)	1830 (12.1)	13329 (87.9)	96.33[d]
Adjunctive general services (1)	710 (18.0)	3227 (82.0)	

Groups: SMI, patients with a diagnosis of serious mental illness; Non-SMI, patients without a diagnosis of serious mental illness.

[a]Binary variable, with 0 denoting patients who did not undergo the procedure and 1 denoting patients who did undergo the procedure.

[b]No analysis was conducted for the diagnostics category, as all patients completed this procedure.

[c]Statistically significant difference (chi-square analysis; $P < 0.05$).

[d]Statistically significant difference (chi-square analysis; $P < 0.01$).

Table 3. Statistical comparison of frequency of visits for each dental procedure in the study groups.

Procedure	No. of visits, mean (SD)		*t*
	SMI group	Non-SMI group	
Diagnostic	4.78 (3.73)	4.07 (2.94)	9.14[a]
Preventive	1.66 (2.87)	1.33 (1.85)	5.73[a]
Restorative	7.87 (13.90)	7.04 (12.57)	2.81[a]
Endodontics	1.08 (2.60)	1.07 (2.59)	0.17
Periodontics	1.58 (2.97)	1.62 (2.84)	−0.72
Removable prosthodontics	5.57 (9.58)	4.22 (8.15)	6.73[a]
Maxillofacial prosthetics	0.00 (0.04)	0.00 (0.06)	−1.85
Implant services	0.58 (2.43)	0.58 (2.23)	0.12
Fixed prosthodontics	1.62 (7.69)	1.93 (8.66)	−1.82
Oral and maxillofacial surgery	3.16 (5.12)	2.23 (4.08)	8.75[a]
Orthodontics	0.06 (0.93)	0.05 (0.76)	0.33
Adjunctive general services	0.54 (1.38)	0.30 (0.76)	8.52[a]

Groups: SMI, patients with a diagnosis of serious mental illness; Non-SMI, patients without a diagnosis of serious mental illness.

[a]Statistically significant difference (*t* test; $P < 0.01$).

received removable prosthodontics procedures compared with 32.6% of self-paying patients without a diagnosis of SMI; this was a statistically significant difference ($P < 0.001$). Among patients with private insurance, the analysis did not find a statistically significant difference between the SMI group (39.4%) and the non-SMI group (32.1%) in receiving removable prosthodontics procedures ($P = 0.23$). Similarly, the analysis did not reveal a statistically significant difference between the SMI group (47.6%) and non-SMI group (34.6%) in receiving removable prosthodontics procedures among patients whose treatment was paid via grants or contracts. These findings underscore the potential impact on dental care policies and the importance of the professional's role in shaping these policies.

The 2 groups were compared based on the frequency of visits for each dental procedure (Table 3). Six of 12 procedures (diagnostic, preventive, restorative, removable prosthodontics, oral and maxillofacial surgery, and adjunctive general services) showed statistically significant differences between the 2 groups, with effect sizes ranging from 0.06 to 0.27 (small). The SMI group had a significantly higher frequency of visits than the non-SMI group. For example, the SMI group had a mean (SD) of 5.57 (9.58) visits for removable prosthodontics procedures vs 4.22 (8.15) removable prosthodontics visits in the non-SMI group. Similar trends were found in the other 5 procedure categories.

A logistic regression analysis was performed to determine if mental health conditions predicted the likelihood of receiving each oral procedure after data were controlled for the patients' demographics and medical history (Table 4). Only the 4 procedures that were significant in the bivariate analysis (preventive, removable prosthodontics, oral and maxillofacial surgery, and adjunctive general services) were included in the logistic regression. After data were controlled for all available demographics and patient medical histories, the SMI group was more likely to receive all 4 procedures. However, only the differences in removable prosthodontics and adjunctive general services were statistically significant ($P < 0.01$), with odds ratios (ORs) of 1.31 and 1.29, respectively. Patients were more likely to receive removable prosthodontics procedures ($P < 0.01$) if they self-identified as tobacco users (OR = 1.54); had a history of endocrine (OR = 1.26) or infectious disease (OR = 1.55); had a history of nervous disorders (OR = 1.27); were Hispanic (OR = 1.39) or Black (OR = 1.36); or were self-paying (OR = 1.28). Asian patients (OR = 0.66) were 34% less likely to receive a removable prosthodontics procedure than their White counterparts ($P < 0.05$). Regarding statistically significant differences in adjunctive general services ($P < 0.05$), patients who identified as Hispanic (OR = 0.64), Black (OR = 0.77), or male (OR = 0.79) were less likely to receive such procedures, while patients with a medical history of nervous system disorders (OR = 1.24) and other major problems (OR = 1.60) or who were self-paying (OR = 1.77) were more likely to receive the adjunctive general services.

Negative binomial regression analysis was used to determine if mental health conditions would predict the frequency of visits for each oral procedure after data were controlled for the patients' demographics and medical history (Table 5). The negative binomial regression included only the 6 procedures that were significant in the bivariate analysis (diagnostic, preventive,

Table 4. Logistic regression analysis (odds ratios) of whether patients received each dental procedure.

Predictor	Preventive	Removable prosthodontics	OMFS	AGS
Oral care habits				
Toothbrushing	1.07	0.87[d]	1.02	0.99
Mouthwash use	1.03	1.02	1.02	1.05
Flossing	1.22[d]	0.82[d]	0.95	1.10[d]
Adults (18 years and older)	0.98[d]	1.05[d]	1.02[d]	0.99[d]
Race[a]				
Black	0.73[d]	1.36[d]	1.03	0.77[d]
Hispanic	0.91	1.39[d]	0.97	0.64[d]
Asian	1.17	0.66[e]	0.83	0.93
Combined American Indian, Hawaiian, and other	1.31	1.15	1.35	1.30
Sex[b]				
Male	0.84[d]	1.08	1.12	0.79[d]
Insurance[c]				
Private insurance	1.07	1.29	1.51	1.23
Self-pay	0.97	1.28[d]	1.24[d]	1.77[d]
Grants/other contract payments	1.12	0.58	1.19	0.51
Medical history				
Blood	0.91	1.05	1.19	1.02
Bone, muscle, joint	1.22[d]	1.12	0.94	1.12
Cardiovascular	1.43[d]	0.96	1.10	1.03
Endocrine	1.06	1.26[d]	1.17[e]	1.02
Gastrointestinal	1.26[d]	0.90	0.90	1.04
Infectious disease	1.12	1.55[d]	0.96	1.03
Nervous disorder	0.92	1.27[d]	1.44[d]	1.24[d]
Respiratory	0.89	1.06	1.12	1.04
Other	1.96[d]	0.94	1.37[d]	1.60[d]
Substance use				
Tobacco	1.25	1.54[d]	1.29	1.10
Alcohol	1.07	0.85	1.15	1.13
Serious mental illness	1.07	1.31[d]	1.16	1.29[d]

Abbreviations: AGS, adjunctive general services; OMFS, oral and maxillofacial surgery.

[a]White is the reference model for race, except for Hispanic. The reference for Hispanic ethnicity is all other (non-Hispanic) groups combined. Other data combined in this analysis include American Indian, Hawaiian, and Native American individuals and those who chose the category "other."

[b]Female is the reference model for sex.

[c]Medicaid is the reference model for insurance status.

[d]Statistically significant difference ($P < 0.01$).

[e]Statistically significant difference ($P < 0.05$).

restorative, removable prosthodontics, oral and maxillofacial surgery, and adjunctive general services). After data were controlled for all available demographics and the patient's medical history, the SMI group, in general, had a higher incidence rate ratio (IRR) of receiving all 6 investigated procedures compared with the non-SMI group. However, differences in the IRRs were significant for only 4 of the 6 procedures: preventive, 1.11 ($P < 0.05$); removable prosthodontics, 1.32 ($P < 0.05$); oral and maxillofacial surgery, 1.17($P < 0.05$); and adjunctive general services, 1.26 ($P < 0.01$). Patients who identified as Hispanic,

Table 5. Negative binomial regression analysis (incidence rate ratios) of frequency of visits.

Predictor	Diagnostics	Preventive	Restorative	Removable prosthodontics	OMFS	AGS
Oral care habits						
Toothbrushing	1.03[d]	1.04	1.06[e]	0.93	0.91[d]	1.03
Mouthwash use	1.00	1.03	0.99	1.01	1.04	1.10[e]
Flossing	1.06[d]	1.12[d]	1.19[d]	0.86[d]	0.89[d]	1.06[e]
Adults (18 years and older)	1.00[d]	0.99[d]	0.99	1.06[d]	1.02[d]	0.99[d]
Race[a]						
Black	1.01	0.82[d]	0.65[d]	1.21[e]	0.87[d]	0.73[d]
Hispanic	1.03	0.87[d]	0.85[e]	1.33[e]	0.77[d]	0.65[e]
Asian	0.98	1.06	0.76[d]	0.51[d]	0.81[e]	0.84
Combined American Indian, Hawaiian, and other	1.16[e]	1.10	1.23	0.87	1.03	0.90
Sex[b]						
Male	1.01	0.95	1.03	1.10	1.21[d]	0.82[d]
Insurance[c]						
Private insurance	1.06	0.85	1.12	1.12	1.28[e]	1.11
Self-pay	1.21[d]	1.00	0.91	1.21[e]	1.36[d]	1.61[d]
Grants/other contract payments	1.41[d]	1.43	0.34[d]	0.31[e]	1.42	0.33[e]
Medical history						
Blood	0.98	0.93	0.98	1.01	1.10	1.04
Bone, muscle, joint	1.00	1.11[e]	1.02	0.97	0.96	1.06
Cardiovascular	1.11[d]	1.18[d]	1.13	1.05	0.97	1.03
Endocrine	1.10[d]	1.15[d]	1.06	1.20	1.11[e]	1.09
Gastrointestinal	1.04	1.16[d]	1.19[d]	0.99	0.92	0.97
Infectious disease	1.05	1.04	0.97	1.26	1.01	1.19
Nervous disorder	1.03	0.94	0.94	1.40[d]	1.32[d]	1.33[d]
Respiratory	1.03	0.95	0.96	0.96	1.07	0.98
Other	1.45[d]	1.88[d]	1.60[d]	1.08	1.17[d]	1.56[d]
Substance use						
Tobacco	1.18[d]	1.20[d]	1.02	1.60	1.46[d]	1.29[e]
Alcohol	1.10[d]	1.04	1.07	0.94	1.08	1.09
Serious mental illness	1.03	1.11[e]	1.02	1.32[e]	1.17[e]	1.26[d]

Abbreviations: AGS, adjunctive general services; OMFS, oral and maxillofacial surgery.

[a]White is the reference model for race, except for Hispanic. The reference for Hispanic ethnicity is all other (non-Hispanic) groups combined. Other data combined in this analysis include American Indian, Hawaiian, and Native American individuals and those who chose the category "other."

[b]Female is the reference model for sex.

[c]Medicaid is the reference model for insurance status.

[d]Statistically significant difference ($P < 0.01$).

[e]Statistically significant difference ($P < 0.05$).

Black, or self-paying had significantly higher IRRs for removable prosthodontics. In contrast, patients who identified as Hispanic (IRR = 0.77; $P < 0.01$), Black (IRR = 0.87; $P < 0.01$), or Asian (IRR = 0.81; $P < 0.05$) had significantly lower IRRs for oral and maxillofacial surgery. A similar pattern of lower IRRs among Hispanic (IRR = 0.65), Black (IRR = 0.73), and Asian (IRR = 0.84) patients was found for adjunctive general services, although the differences were significant only among Hispanic ($P < 0.05$) and Black ($P < 0.01$) patients.

Patients with a history of tobacco use showed significantly increased IRRs for the oral procedure categories of diagnostics, preventive, oral and maxillofacial surgery, and adjunctive general services. Poor toothbrushing and flossing habits were significantly associated with increased IRRs for diagnostics and restorative services. At-home oral care habits can be improved through instructions to caregivers, patients, and providers. This was demonstrated in a previous study by the principal investigator of the present study.[19]

Discussion

This study confirmed the existence of oral health disparities related to frequency and distribution of care based on ADA CDT codes between a population with SMI and a population without SMI. After controlling for demographics and medical history, the group with SMI had higher rates of receiving procedures related to oral and maxillofacial surgery (such as extractions) and removable prosthodontics procedures than the group without SMI. Based on these findings, it can be inferred that their dental conditions included extensive caries, making the tooth or teeth hopeless and resulting in more invasive treatments. A plausible explanation may be that the population with SMI experiences a higher number of missing teeth than that without SMI. This aligns with the findings of other researchers, who have determined that there is a greater need for dental extractions in those with SMI than in those without a diagnosis of SMI.[4,15-17] Loss of dentition impacts oral health–related quality of life as the diet changes to one that is less healthy and richer in starchier, carbohydrate-rich foods.[19] Additionally, it was found that the group with SMI had a higher return visit rate than those without SMI. This suggests that the dental conditions of individuals with SMI may have been more complex, requiring multiple appointments for treatment.

The present study also found that patients with SMI had a higher rate of preventive services than patients without a diagnosis of SMI. This contrasts with the findings of researchers who determined that preventive care is lacking in this population.[4] This may have occurred because the present study was conducted at a large public dental school where all patients receive preventive services; thus, it may be difficult to generalize this finding to the larger population.

The researchers searched the literature for published studies related to Medicaid or insurance use for dental work for persons with SMI to determine which procedures were completed most frequently. No such studies were found. It is possible that the increased rate of extractions found in the present study might result from a lack of regular access to preventive care (patients seeking care when oral conditions become severe), delayed dental treatment due to not having insurance coverage for oral health, and difficulty in finding clinics that accept the lower rates of payment by Medicaid, which is the most common healthcare coverage among individuals with SMI. The present study adds new information to the current body of literature, as this research found that the group with SMI had a higher rate of removable prosthodontics procedures than the non-SMI group. It can be assumed that having more missing teeth would result in a higher rate of removable prosthetic appliances. For self-paying patients, the choice of removable appliances may be a result of cost, as removable prosthetic appliances are less expensive than fixed prosthodontic appliances such as crowns and bridges. For those with Medicaid and other government-issued insurance, the policies require predetermination for major dental work. It is possible that Medicaid may approve a removable prosthodontic appliance if the patient has several missing teeth. This would be a more cost-effective way of restoring the dentition than fixed prosthodontic work.

Some other noteworthy outcomes of the analyses include the finding that patients who received removable prosthodontics procedures were more likely to be tobacco users and to have a history of endocrine or infectious disease and poor physical health. This supports the findings of previous studies. A meta-analysis found a causal relationship between smoking and tooth loss.[22] A systematic review found that tooth loss is also associated with diabetes mellitus–related morbidities, including a higher prevalence of heart disease, diabetic retinopathy, metabolic syndrome, and chronic kidney disease.[33] Additionally, the present study noted that social determinants of health factors, such as being a member of a racial or ethnic minority, as well as not having dental health insurance, resulted in poorer oral health. These findings are similar to those of other published studies.[34,35]

The present study findings highlight the need for timely and quality oral care for the population with SMI. They also serve as a call for both oral and mental health providers to coordinate efforts in providing education on the importance of oral health and preventive oral hygiene practice to individuals with SMI as well as to advocate for greater access to oral care and fewer treatment barriers for this population. Understanding and mitigating social determinants of health is critical to improving healthcare delivery. These determinants—income, education, housing, and cultural norms—profoundly impact access to care, treatment outcomes, and overall well-being.[17,34] However, there remains a gap in comprehensive research that specifically examines how these factors intersect with patient experiences and healthcare delivery. By examining real-world scenarios, researchers can uncover patterns, disparities, and opportunities for intervention. Such insights can lead to evidence-based recommendations for delivering patient-centered care that considers medical needs and the broader context in which patients live.

The present study has some limitations. This study utilized a large EHR data set to answer the proposed research question. Although this data set provided rich clinical information for research, cleaning and preprocessing the data were significant challenges. Not all patient information was documented in a ready-to-analyze format; most information was documented in free text, so NLP pipelines were applied to process such data

sets in an analyzable format. The data cleaning and preprocessing accounted for more than 90% of the time and effort in this research. However, the methods outlined in this article provide a base for other researchers that may help them retrieve and utilize similar data sets for their research.

The study results have limited generalizability, as the data were obtained from a single institute. An additional limitation is that the medical history was self-reported, requiring accuracy on the part of the patient. Furthermore, some confounding variables, such as the patient's diet, were not considered in this study, and social determinants of health information could not be added to the analysis, as such data are not collected in the EHR. Despite these limitations, this study provides a framework to process big electronic data on dental care for clinical research.

In the future, the data sets will be made publicly available for other researchers to use for additional analyses. Machine learning models will also be run on this data set to build a prediction model to determine oral risk outcomes in the population with SMI. Future studies should also conduct surveys and interviews to evaluate this population's oral health–related quality of life.

Conclusion

The results of the present study suggest that the intersection of mental health and oral health necessitates a more integrated approach to patient care. By establishing partnerships across disciplines, oral health providers and mental health professionals may be better able to address the complex needs of this population. Future research should explore the effectiveness of such integrated care models, including preventive care, in improving the oral health outcomes of individuals with SMI.

Author affiliations

Department of Pediatric Dentistry and Community Health, Rutgers University, School of Dental Medicine, Newark, New Jersey (Singhal, York, Gold-Rosenbach); Department of Interdisciplinary Studies, Rutgers University, School of Health Professions, Newark, New Jersey (Singhal, Jia); Department of Psychiatric Rehabilitation and Counseling Professions, Rutgers University, School of Health Professions, Piscataway, New Jersey (Gao); Department of Computer Science, School of Arts and Sciences, Rutgers University, Newark, New Jersey (Ginu); Villanova University, Villanova, Pennsylvania (Arya); Center for Dental Informatics and Artificial Intelligence, Department of Oral Health Sciences, Temple University Kornberg School of Dentistry, Philadelphia, Pennsylvania (Patel).

Correspondence

Vaishali Singhal, DMD, PhD, MS (singhava@shp.rutgers.edu).

Conflicts of interest

None reported.

Funding

The authors are grateful to the New Jersey Health Foundation for funding this project.

Acknowledgments

The authors would like to acknowledge Lisa Pilch, Debbie Ceci, and Mark Segal, Rutgers School of Dental Medicine Office of Information Technology, for extracting data from axiUm patient records.

References

1. National Institute of Mental Health. Mental illness. Updated September 2024. Accessed May 7, 2025. https://www.nimh.nih.gov/health/statistics/mental-illness#
2. McGinty EE, Kennedy-Hendricks A, Linden S, Choksy S, Stone E, Daumit GL. An innovative model to coordinate healthcare and social services for people with serious mental illness: a mixed-methods case study of Maryland's Medicaid health home program. *Gen Hosp Psychiatry.* 2018;51:54-62. doi:10.1016/j.genhosppsych.2017.12.003
3. Wilson AB, Phillips J, Parisi A, Ishler KJ, Villodas M, Francis A. Patterns in Medicaid coverage and service utilization among people with serious mental illnesses. *Community Ment Health J.* 2022;58(4):729-739. doi:10.1007/s10597-021-00878-7
4. Walker ER, Cummings JR, Hockenberry JM, Druss BG. Insurance status, use of mental health services, and unmet need for mental health care in the United States. *Psychiatr Serv.* 2015;66(6):578-584. doi:10.1176/appi.ps.201400248
5. Hall JP, LaPierre TA, Kurth NK. Oral health needs and experiences of Medicaid enrollees with serious mental illness. *Am J Prev Med.* 2018;55(4):470-479. doi:10.1016/j.amepre.2018.05.013
6. McKibbin CL, Kitchen-Andren KA, Lee AA, Wykes TL, Bourassa KA. Oral health in adults with serious mental illness: needs for and perspectives on care. *Community Ment Health J.* 2015;51(2):222-228. doi:10.1007/s10597-014-9758-z
7. Romain AJ, Marleau J, Baillot A. Impact of obesity and mood disorders on physical comorbidities, psychological well-being, health behaviours and use of health services. *J Affect Disord.* 2018;225:381-388. doi:10.1016/j.jad.2017.08.065
8. Gao N, Eissenstat SJ, Giacobbe G. Poor physical health: a major barrier to employment among individuals with serious mental illness. *J Vocat Rehabil.* 2020;52(1):101-108. doi:10.3233/JVR-191063
9. Julià M, Vanroelen C, Bosmans K, Van Aerden K, Benach J. Precarious employment and quality of employment in relation to health and well-being in Europe. *Int J Health Serv.* 2017;47(3):389-409. doi:10.1177/0020731417707491
10. O'Neill EA. Relationships between physical health and employment among people with serious mental illness. *Soc Work Res.* 2021;45(1):30-42. doi:10.1093/swr/svaa025
11. Murphy PA. From mental illness to mental health: improving access to care. *J Midwifery Womens Health.* 2017;62(6):655-656. doi:10.1111/jmwh.12700
12. Thomas KC, Ellis AR, Konrad TR, Holzer CE, Morrissey JP. County-level estimates of mental health professional shortage in the United States. *Psychiatr Serv.* 2009;60(10):1323-1328. doi:10.1176/ps.2009.60.10.1323
13. Cummings JR, Wen H, Ko M, Druss BG. Geography and the Medicaid mental health care infrastructure: implications for health care reform. *JAMA Psychiatry.* 2013;70(10):1084-1090. doi:10.1001/jamapsychiatry.2013.377
14. Medicaid and CHIP Payment and Access Commission. MACPAC response to Senate Finance RFI on behavioral health. November 15, 2021. Accessed May 7, 2025. https://www.macpac.gov/wp-content/uploads/2021/11/MACPAC-response-to-Senate-Finance-RFI-on-behavioral-health.pdf
15. Brondani MA, Alan R, Donnelly L. Stigma of addiction and mental illness in healthcare: the case of patients' experiences in dental settings. *PLoS One.* 2017;12(5):e0177388. doi:10.1371/journal.pone.0177388
16. Brondani M, Alan R, Donnelly L. The role of an educational vignette to teach dental students on issues of substance use and mental health disorders in patients at the University of British Columbia: an exploratory qualitative study. *BMC Med Educ.* 2021;21(1):360. doi:10.1186/s12909-021-02767-9
17. Lam PC, John DA, Galfalvy H, Kunzel C, Lewis-Fernández R. Oral health-related quality of life among publicly insured mental health service outpatients with serious mental illness. *Psychiatr Serv.* 2019;70(12):1101-1109. doi:10.1176/appi.ps.201900111
18. Zechner, MR, Singhal V, Murphy AA, York J, Karyczak S, Muhammad A. Dental pre-doctoral student perceptions about serious mental illness: concerns and role clarification. *J Dent Educ.* 2023;87(5):639-645. doi:10.1002/jdd.13156
19. Singhal V, Heuer AJ, York J, Gill KJ. The effects of oral health instruction, and the use of a battery-operated toothbrush on oral health of persons with serious mental illness: a quasi-experimental study. *Community Ment Health J.* 2021;57(2):357-364. doi:10.1007/s10597-020-00657-w
20. Knaak S, Mantler E, Szeto A. Mental illness-related stigma in healthcare: barriers to access and care and evidence-based solutions. *Healthc Manage Forum.* 2017;30(2):111-116. doi:10.1177/0840470416679413
21. Vistorte AOR, Ribeiro WS, Jaen D, Jorge MR, Evans-Lacko S, Mari JJ. Stigmatizing attitudes of primary care professionals towards people with mental disorders: a systematic review. *Int J Psychiatry Med.* 2018;53(4):317-338. doi:10.1177/0091217418778620

22. Kisely S, Quek LH, Pais J, Lalloo R, Johnson NW, Lawrence D. Advanced dental disease in people with severe mental illness: systematic review and meta-analysis. *Br J Psychiatry.* 2011;199(3):187-93. doi:10.1192/bjp.bp.110.081695
23. Zusman SP, Ponizovsky AM, Dekel D, et al. An assessment of the dental health of chronic institutionalized patients with psychiatric disease in Israel. *Spec Care Dentist.* 2010;30(1):18-22. doi:10.1111/j.1754-4505.2009.00118.x
24. Rahman KMT, Khalequzzaman M, Khan FA, et al. Factors associated with the nutritional status of the older population in a selected area of Dhaka, Bangladesh. *BMC Geriatr.* 2021;161. doi:10.1186/s12877-021-02068-2
25. Maremmani AGI, Aglietti M, Intaschi G, Bacciardi S. Substance use/dependence in psychiatric emergency setting leading to hospitalization: predictors of continuity of care. *Int J Environ Res Public Health.* 2022;19(2):760. doi:10.3390/ijerph19020760
26. Cook JA, Burke-Miller J, Razzano LA, Steigman PJ, Jonikas JA, Santos A. Serious mental illness, other mental health disorders, and outpatient health care as predictors of 30-day readmissions following medical hospitalization. *Gen Hosp Psychiatry.* 2021;70:10-17. doi:10.1016/j.genhosppsych.2021.02.004
27. Martin C, Koep E, White J, Belland A, Waters H, Forma F. Treatment compliance communications between patients with severe mental illness and treating healthcare providers: a retrospective study of documentation using healthcare reimbursement claims and medical chart abstraction. *Pragmat Obs Res.* 2021;12:49-63. doi:10.2147/POR.S303453
28. Dixon L, Goldberg R, Iannone V, et al. Use of a critical time intervention to promote continuity of care after psychiatric inpatient hospitalization. *Psychiatr Serv.* 2009;60(4):451-458. doi:10.1176/ps.2009.60.4.451
29. Patel JS, Su C, Tellez M, et al. Developing and testing a prediction model for periodontal disease using machine learning and big electronic dental record data. *Front Artif Intell.* 2022;5:979525. doi:10.3389/frai.2022.979525
30. Patel JS, Brandon R, Tellez M, et al. Developing automated computer algorithms to phenotype periodontal disease diagnoses in electronic dental records. *Methods Inf Med.* 2022;61(S 02):e125-e133. doi:10.1055/s-0042-1757880
31. American Association of Periodontology. Staging and grading periodontitis. August 2019. Accessed May 25, 2025. https://www.perio.org/wp-content/uploads/2019/08/Staging-and-Grading-Periodontitis.pdf
32. American Dental Association. *CDT 2023: Current Dental Terminology.* American Dental Association; 2023.
33. Raju K, Taylor GW, Tahir P, Hyde S. Association of tooth loss with morbidity and mortality by diabetes status in older adults: a systematic review. *BMC Endocr Disord.* 2021;21(1):205. doi:10.1186/s12902-021-00830-6
34. Centers for Disease Control and Prevention. *Oral Health Surveillance Report: Trends in Dental Caries and Sealants, Tooth Retention, and Edentulism, United States: 1999–2004 to 2011–2016.* Centers for Disease Control and Prevention, US Dept of Health and Human Services; 2019. https://stacks.cdc.gov/view/cdc/82756
35. Corr A, Wenderoff J. Inequitable access to oral health care continues to harm children of color. March 11, 2022. *Pew Charitable Trusts.* https://www.pewtrusts.org/en/research-and-analysis/articles/2022/03/11/inequitable-access-to-oral-health-care-continues-to-harm-children-of-color