Evaluation of the Safer Use of Antipsychotics in Youth (SUAY) Study on Population Level Antipsychotic Initiation: An Interrupted Time Series Analysis

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Abstract

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Background: Atypical antipsychotics carry a high risk profile and may be prescribed for youth with conditions where other first line treatments are more appropriate. This study aimed to evaluate the population-level effectiveness of the Safer Use of Antipsychotics in Youth (SUAY) intervention, which aimed to reduce inappropriate atypical antipsychotic prescribing.

Methods: We conducted an interrupted time series analysis using segmented regression to measure changes in prescribing trends of antipsychotic initiation rates pre- and post- SUAY intervention at four U.S. health systems between 2013 and 2020.

Results: In our overall model, adjusted for age and insurance type, antipsychotic initiation rates decreased by 0.73 (95% CI: 0.30, 1.16) prescriptions per 10,000 person months before the SUAY intervention. In the first quarter following the intervention, there was an immediate decrease in the rate of antipsychotic initiations of 6.57 (95% CI: 0.99, 12.15) prescriptions per

10,000 person months. When comparing the post-intervention period to the pre-intervention period, there was an increase of 1.09 (95% CI: 0.32, 1.85) prescriptions per 10,000 person months, but the increasing rate in the post-intervention period alone was not statistically significant (0.36 prescriptions per 10,000 person months, 95% CI: -0.27, 0.99).

Conclusion: Further analyses are needed to confirm these unexpected results. The declining trend of antipsychotic initiation seen between 2013 and 2018 (pre-SUAY intervention) may have naturally reached a level at which prescribing was clinically warranted and appropriate, resulting in the rate leveling out. The COVID-19 pandemic, which began in the final three quarters of the post-intervention period, may also have increased antipsychotic medication initiation.

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INTRODUCTION

Since their development in the 1990s, atypical antipsychotics have been increasingly prescribed for youth with conditions where antipsychotics may not be an appropriate first line treatment, including attention deficit hyperactivity disorder (ADHD), disruptive behavior disorders, Tourette's Syndrome, anxiety, depression, eating disorders, and sleep disorders [1-4]. One study found that in 2004, 70.2% of privately insured youth ages 6-17 and 73.2% of Medicaid insured youth ages 6-17 receiving antipsychotics in seven states did not have a diagnosis of a psychotic disorder, bipolar disorder, autism spectrum disorder, or developmental disability – the diagnoses for which antipsychotics are approved [4, 5]. Other studies report that most antipsychotic medication use in youth is for disruptive behavior, suggesting that antipsychotics may be over-used or that access to appropriate first line treatment is insufficient [3]. This is worrisome because atypical antipsychotics carry many side effects including weight gain, cardiometabolic risk, prolactin elevation, sedation, and extrapyramidal symptoms (e.g., dystonia, tardive dyskinesia) [1, 6-10].

Due to the high risk profile, increasing trends of antipsychotic prescribing in the U.S. in the 1990s and 2000s elicited widespread concern and prompted states to implement oversight programs, including prior authorization and database and peer review processes, some of which may be effective in reducing antipsychotic use [11-17]. Multiple studies have shown that antipsychotic prescribing trends rose in the 1990s and early 2000s, peaked in the late 2000s, and have since started declining slightly [18-27]. However, there is limited recent data on prescribing trends, despite initiatives to decrease potentially inappropriate prescribing [28]. In addition, previous studies have largely relied on claims data, focused separately on either private or Medicaid insured youth, and examined overall prescribing trends for all diagnoses – both those

that are appropriate for first line antipsychotic treatment and those that are not. Disaggregation of diagnosis type (e.g., excluding people diagnosed with psychotic disorders) is necessary to accurately estimate the effectiveness of interventions geared at potentially inappropriate antipsychotic prescribing for conditions where there are safer first line treatments.

The Safer Use of Antipsychotics in Youth (SUAY) study was a NIMH funded pragmatic randomized controlled trial with the aim of reducing antipsychotic use in youth and addressing some of the limitations of previous studies [28]. Recruitment was conducted between May 2018 and December 2020 in four U.S. health systems: Kaiser Permanente (KP) Washington, KP Northwest, KP Colorado, and Nationwide Children's Hospital (NCH) in Columbus, Ohio [28]. The SUAY intervention used a novel approach that included automated recruitment, medication review and consultation from a study psychiatrist, navigation assistance for families, and expedited access to psychosocial care and telemental health [28].

Providers were recruited to the SUAY study if they opened a new medication order dialogue box and selected an antipsychotic in Epic for an eligible patient [28]. Providers were randomized to receive either the intervention or control best practice alert (BPA) and their patients would receive different follow up options accordingly [28]. Given that SUAY recruitment was driven by antipsychotic initiation, the SUAY study was unable to collect information on providers' decision making when they did not order new antipsychotic prescriptions. Thus, it was not possible to observe how providers' prescribing behavior was influenced by external factors (guidelines, oversight programs), by knowledge of SUAY study activities (Hawthorne effect) [29], or by a previous exposure to SUAY intervention components, which could affect the treatment plan of patients to follow. While this prescribing behavior

couldn't be captured by the clinical workflow, it may be captured in overall population rates of initiation for all youth "at risk" of a prescription.

In order to identify and adjust for any underlying trends in initiation of antipsychotics at the health system population level (rather than just SUAY participants) and evaluate the effectiveness of the SUAY intervention, we conducted an interrupted time series analysis using segmented regression to measure changes in the level and slope of antipsychotic initiation rates pre- and post- SUAY intervention.

We hypothesized that 1) the SUAY intervention accelerated the declining rate antipsychotic initiation rates; and 2) there was significant variation in the change in trend pre- and post- intervention between stratified subgroups (effect modification).

METHODS

Study Design

In this retrospective, quasi-experimental, single-group interrupted time series analysis [30-33], we used segmented regression to evaluate changes in the level and slope of antipsychotic initiation rates for youth aged 3-17 years who did not have a diagnosis for a psychotic disorder, bipolar disorder, autism spectrum disorder, or developmental disability (SUAY eligible population), at a health systems population level before and after SUAY was implemented. We also conducted stratified analyses by study site, age group (3-12, 13-17 years), gender (male, female), race (White, Non-Hispanic; Youth of Color), and insurance type (Commercial, Medicaid).

Study Setting

We examined population level rates of antipsychotic initiations at the four U.S. health systems where SUAY was implemented: Kaiser Permanente (KP) Washington, KP Northwest, KP Colorado, and Nationwide Children's Hospital (NCH) in Columbus, Ohio [28]. At NCH, patients were limited to those who had encounters in either the Psychiatry or Developmental and Behavioral Pediatrics departments [28]. To ensure comparability, we also limited patients at the KP sites to those who had visits in mental health specialty departments. The SUAY study deliberately chose sites with different characteristics to increase generalizability of study findings [28]. The three KP sites use integrated care models, allowing for easier coordination and medical record sharing between pediatricians, child and adolescent psychiatrists, and therapists [28]. NCH represents a traditional, fee-for-service care model [28]. NCH also sees more acutely ill patients than the KP sites by virtue of being a quaternary pediatric hospital and treats a greater proportion of youth insured by Medicaid [28]. At three of the sites (KP Washington, KP Colorado, and NCH), the SUAY intervention began in May 2018. At KP Northwest, the intervention began in May 2019, resulting in four extra pre-intervention time periods (quarters) and four fewer post-intervention time periods (quarters). We excluded these four extra pre-intervention time periods, where we only had data from KP Northwest, as they skewed the pre-intervention trend.

Study Participants

We used similar inclusion and exclusion criteria to those used in the SUAY study [28]. For the crude antipsychotic medication initiation rate numerator, we included incident antipsychotic

prescriptions for patients ≥3 and <18 years of age. We excluded prescriptions if: the antipsychotic was initiated in an inpatient, urgent care, or emergency department setting; the patient had a diagnosis of a psychotic disorder, mania, autism spectrum disorder, or intellectual disability; the antipsychotic was prochlorperazine (Comazol®); an antipsychotic was ordered within the prior 180 days for the patient (short term orders placed by a "doc of the day" did not count toward the 180 day wash out period); the patient primary language was not English; or the prescription order status was missing or unknown (less than 5% of orders).

For the antipsychotic initiation rate denominator, we included all patients from the study sites who were ≥3 and <18 years of age at the time of their visit, who had a visit with an eligible provider in a mental health specialty department in the current month and at least one visit in the prior 11 months, and who did not have a diagnosis of a psychotic disorder, mania, autism spectrum disorder, or intellectual disability (SUAY eligible population). As youth could be eligible in multiple months, our design is an open cohort wherein youth continually enter and leave the population. Accordingly, the denominator does not represent the number of individuals treated at each of these sites, but rather an aggregate total number of youths

each month who could, in principle, have been prescribed atypical antipsychotics. Youth with Medicaid insurance at KP Colorado were excluded from these analyses, as we did not have accurate information for these youth.

Data Collection

We used aggregated administrative and electronic health record data on eligible patients and providers compiled by a Kaiser Permanente Washington Health Research Institute (KPWHRI) programmer. Data included patient demographics (age, gender, race, insurance type) and medications ordered. For the original SUAY study, Institutional Review Boards at each site approved waiver of consent to use records data to identify clinicians and participants, waiver of consent for randomization to usual care or offer of navigation, an abbreviated consent procedure at the time navigation was offered, and waiver of informed consent to use records data to ascertain study outcomes. For this data only analysis, the Kaiser Permanente Washington Institutional Review Board approved use of aggregated, summary data from the four sites.

Data Analysis

In this interrupted time series analysis, we used segmented regression to measure changes in the level and slope of antipsychotic initiation rates in the post-SUAY time period as compared to the pre-SUAY time period [30-33]. The pre-intervention trend projected into the intervention period served as the counterfactual [34]. Using the *itsa* command in Stata, we fit an ordinary least-squares regression model using Newey-West standard errors [34].

We assumed the following model for our interrupted time series:

$$\text{Rate}_t = \beta_0 + \beta_1 \text{time}_t + \beta_2 \text{SUAY}_t + \beta_3 \text{time\_after}_t + \epsilon_t \quad \textbf{(Model 1)}^1$$

Rate_t is the aggregated outcome variable, the crude rate of antipsychotic initiations per 10,000 person months in the SUAY eligible population following a linear model, at each time point (month) *t*. We calculated rates monthly but report the average monthly rates over each quarter, centered on the study start month, due to small numbers of new antipsychotic orders during some months. Aggregating the rates to quarterly observations helped reduce the level of variability at each time point and facilitated trend comparison over time [31]. We evaluated this variability and seasonality and corrected for autocorrelation up to the fourth order (four quarters) using the Cumby-Huizinga test for autocorrelation and a type-1 error of 0.05.

Time_t is the time (in months, aggregated to quarters) since the start of the baseline data collection period. β_0 is the intercept, or starting rate of antipsychotic initiation at time zero. β_1 is the slope, or baseline trend, of the rate of antipsychotic initiations before the introduction of the SUAY intervention. β_2 is the change in the rate of antipsychotic initiation that occurs in the month immediately following the introduction of the SUAY intervention compared with the counterfactual. SUAY_t is a binary dummy variable indicating when the SUAY intervention went into effect (0 for pre-intervention, 1 for intervention). β_3 is the difference between the slopes of the rate of antipsychotic initiations pre-intervention and after the introduction of the SUAY intervention. Time_after_t is an interaction term, measuring the time since the start of intervention, starting in the month immediately following the start of the intervention. ϵ_t is the random variability not explained by the model [31].

[1]Adjusted for the pre- and post- composition differences in age and insurance type using direct standardization in the overall analysis, but not in the stratified sub-group analyses.

In our analyses, we looked for statistically significant values of β_2 and β_3 using a type-1 error of 0.05. In our model, a statistically significant β_2 would indicate that the SUAY intervention had an immediate statistically significant impact on the rate of antipsychotic initiations (shift in the intercept). We believed this to be unlikely, as providers encountered the intervention components at different times and sudden behavior change in prescribing is extremely uncommon [35-37]. A statistically significant β_3 would indicate that the SUAY intervention had an effect over time on the rate of antipsychotic initiations. We hypothesized that β_3 would be negative and statistically significant in the overall analysis and all stratified analyses. The model described above allowed us to control for the baseline rate and trend of antipsychotic initiations before the SUAY intervention was implemented [31]. This model also assumed the initiation trends were linear, which we found to be true [30].

The single-group interrupted time series model assumes any time-varying unmeasured confounders, such as other policy implementations, can be differentiated from the intervention variable [34]. We hypothesized that there may have been a competing intervention effect from a previous EHR alert at NCH prior to the SUAY study that directed providers to order lab assessments along with antipsychotic orders. To test this assumption and to differentiate between the effect of that previous BPA, or other time-varying confounders, and the SUAY intervention, we tested for interruptions in the trend of the β_2 and β_3 variables at the median time point of the preintervention period [34].

RESULTS

Baseline Characteristics

In our overall SUAY eligible population, there were 11,233 monthly average eligible youth in the 21 quarters pre-SUAY intervention and 12,460 in the 6-10 quarters post-SUAY intervention (Table 1). A majority of our SUAY eligible youth were patients at Nationwide Children's Hospital (NCH) (69.3% in the pre-period and 73% in the post-period), were between 3 and 12 years of age (58% in the pre-period and 53.5% in the post-period), were White, Non-Hispanic (64.9% in the pre-period and 65.7% in the post-period), and had commercial insurance (69.8% in the pre-period and 54.7% in the post-period) (Table 1). We adjusted for the pre- and post- composition differences in age and insurance type using direct standardization. We used the distribution of age and insurance type in the quarter during which the SUAY intervention began. The proportion of females in the SUAY eligible population shifted from 48.3% in the pre-period to 50.1% in the post-period (Table 1). Visual inspection of the initiation rates across our pre- and post- time periods revealed a declining rate of initiation beginning in January 2013, which appeared to level out or slightly increase again starting in 2019 (Figure 1).

Overall analysis

In our overall model, adjusted for age and insurance type, the rate of antipsychotic initiation in the study population at the beginning of the baseline data collection period (January 2013 or 2014, depending on site) was 52.44 (95% Confidence Interval (CI): 46.53, 58.36) prescriptions per 10,000 person months. This rate decreased prior to the start of the SUAY intervention by 0.73 (95% CI: 0.30, 1.16) prescriptions per 10,000 person months. In the first quarter after the intervention began (β_2), there was an immediate decrease in the rate of antipsychotic initiations of 6.57 (95% CI: 0.99, 12.15) prescriptions per 10,000 person months. In the post-intervention period, the rate of antipsychotic initiations increased at a rate of 0.36 (95% CI: -0.27, 0.99) prescriptions per 10,000 person months, but this estimate was too

imprecise to rule out chance. When comparing the post-intervention period to the pre-intervention period (β_3), there was an increase of 1.09 (95% CI: 0.32, 1.85) prescriptions per 10,000 person months (Table 2, Figure 2).

Stratified Sub-group Analyses

Stratified by site, at KP Northwest, there was an increase in the rate of antipsychotic initiations in the post-intervention period relative to the pre-intervention period (β_3) of 3.61 (95% CI: 2.24, 4.99) prescriptions per 10,000 person months, and an increase in the rate of initiations in the post-intervention period of 2.19 (95% CI: 1.33, 3.04) prescriptions per 10,000 person months (Table 2, Figure 3). At NCH, we did see evidence of a competing intervention effect, possibly from a previous EHR alert prior to the SUAY study that directed providers to order lab assessments along with antipsychotic orders (Table 2).

Stratified by age, for those 3-12 years of age, there was an immediate decrease in the rate of antipsychotic initiations in the first quarter after the intervention began (β_2) of 7.05 (95% CI: 0.60, 13.51) prescriptions per 10,000 person months (Table 2, Figure 4). For those 13-17 years of age, there was an increase in the rate of antipsychotic initiations in the post-intervention period relative to the pre-intervention period (β_3) of 1.61 (95% CI: 0.44, 2.78) prescriptions per 10,000 person months (Table 2, Figure 4).

Stratified by gender, in females, there was an immediate decrease in the rate of antipsychotic initiations in the first quarter after the intervention began (β_2) of 8.92 (95% CI: 2.22, 15.62) prescriptions per 10,000 person months and an increase in the rate of antipsychotic initiations in the post-intervention period relative to the pre-intervention period (β_3) of 1.34 (95% CI: 0.48, 2.20) prescriptions per 10,000 person months. In the post-intervention period, the rate

of antipsychotic initiations for females increased at a rate of 0.96 (95% CI: 0.33, 1.60) prescriptions per 10,000 person months (Table 2, Figure 5).

Stratified by race, for White, Non-Hispanic youth, there was an immediate decrease in the rate of antipsychotic initiations in the first quarter after the intervention began (β_2) of 12.82 (95% CI: 5.06, 20.58) prescriptions per 10,000 person months and an increase in the rate of antipsychotic initiations in the post-intervention period relative to the pre-intervention period (β_3) of 1.50 (95% CI: 0.61, 2.38) prescriptions per 10,000 person months (Table 2, Figure 6).

Stratified by insurance type, for youth with commercial insurance, there was an immediate decrease in the rate of antipsychotic initiations in the first quarter after the intervention began (β_2) of 15.77 (95% CI: 7.59, 23.94) prescriptions per 10,000 person months and an increase in the rate of antipsychotic initiations in the post-intervention trend relative to the pre-intervention trend (β_3) of 1.81 (95% CI: 0.97, 2.66) prescriptions per 10,000 person months. In the post-intervention period, the rate of antipsychotic initiations for youth with commercial insurance increased at a rate of 0.78 (95% CI: 0.09, 1.47) prescriptions per 10,000 person months (Table 2, Figure 7).

DISCUSSION

In this retrospective, quasi-experimental, interrupted time series analysis, we found that the SUAY intervention may have contributed to a temporary, immediate decrease in the rate of antipsychotic initiations, followed by an increased rate of antipsychotic initiations in the post-intervention time period relative to the pre-intervention time period for SUAY eligible youth at four U.S. health systems. This finding was also true in some but not all of the stratified sub-groups. Only in the stratified sub-groups of youth at KP Northwest, females, and youth with

commercial insurance, was there a statistically significant increase in initiation rates when looking at the post-intervention time period alone. We observed high variation in initiation rates, even when aggregated by quarter, which made it difficult to interpret the results.

One of the goals of the SUAY intervention was to reduce potentially inappropriate antipsychotic prescribing for youth with diagnoses where other first line treatments might be more appropriate, such as antidepressants, stimulants, or first-line psychosocial therapy. However it's possible that the declining trend of antipsychotic initiation seen between 2013 and 2018 naturally reached a level at which prescribing was clinically warranted and appropriate, regardless of the SUAY intervention. SUAY study Child and Adolescent Psychiatrists (CAPs) performed passive second opinion medication reviews and agreed with around half of the prescriptions (R.B. Penfold, personal communication, May 25, 2022). Additionally, the SUAY study found that a higher percentage of youth in the study were engaged in therapy from the beginning than originally anticipated, further indicating that some of the prescribing in the SUAY population may have been appropriate.

While we were able to test for competing trends in the pre-intervention time period by using the median of the pre-intervention time period as a pseudo start point, there were not enough time periods in the post-intervention to do a similar test. It's possible that the leveling out or slight uptick in antipsychotic initiation rates beginning in 2018-2019 is part of a larger trend. Similarly, it is clear that the pandemic has had an impact on youth mental health [38-44] and has changed the way patients interact with providers (e.g. telehealth visits) [45], both of which are likely to have impacted antipsychotic initiation rates beginning in 2020. Thus, we cannot rule out that the pandemic increased antipsychotic medication initiation.

This analysis filled gaps in the existing literature by reporting trends in antipsychotic initiation rates from 2013 to 2020, including both commercially and publicly insured patients, focusing only on youth with conditions for which antipsychotics are not an appropriate first line treatment, and utilizing prescription order data as opposed to administrative claims data from prescription fills. Prescription order data allowed us to measure and focus on provider prescribing behaviors as opposed to patient behaviors. Stratified analyses helped us identify any differences in prescribing trends by health system model, age, gender, race, and insurance type.

LIMITATIONS

Collecting data on a control population was not feasible for this analysis. However, a strength of the interrupted time series model is that it is possible to perform a robust analysis without a control group and sufficiently address threats to internal validity [31, 34].

Following the design of the SUAY study, the rate numerator includes ordered prescriptions as opposed to filled prescriptions, and includes new prescriptions as opposed to prevalent prescriptions, as it is less likely that a best practice alert would change provider behavior for refill orders or for medication that a patient had already used. There could be subgroup related differences in preferences for starting new medications and filling prescribed medications that we are unable to measure. However, the choice to use incident prescription order data is a unique strength of this study because it allows us to isolate and measure the effect of the intervention on provider prescribing behavior.

Limiting the SUAY eligible population to those who had visits in mental health specialty departments limits generalizability to those with access to psychiatrists. However, this matches our clinical population – KP members and those visiting NCH do, by definition, have access to

psychiatrists. In addition, while the SUAY study deliberately chose sites with different characteristics to increase generalizability of study findings, there may still be limited generalizability to smaller healthcare settings and/or other geographic regions of the United States and elsewhere. While we adjusted for age and insurance group in our overall model, we could not adjust for these in the stratified sub-group analyses by virtue of using aggregate data.

CONCLUSION

The rate of antipsychotic initiations in youth age 3-17 who did not have a diagnosis for a psychotic disorder, bipolar disorder, autism spectrum disorder, or developmental disability followed a decreasing trend from 2013 to 2018, at which point it leveled off and may have since started increasing. It is unclear if this is a result of the SUAY-intervention or part of a larger trend, and more analyses with prescribing data from recent years are needed. Future analyses should also consider using the COVID-19 pandemic start point as a time series interruption point, as the pandemic has had an impact on youth mental health [38-44] and has changed the way patients interact with providers (e.g. telehealth visits) [45].

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Table 1. Sociodemographic characteristics of the Safer Use of Antipsychotics in Youth (SUAY) eligible population, pre- and post-SUAY intervention.

Characteristic	Average Monthly Eligible Youth[†], (%)	
	64 months Pre-SUAY Intervention (n=11,233)	32 months Post-SUAY Intervention[‡] (n=12,460)
Site Location[‡]		
KP Washington	789 (7.0)	836 (6)
KP Colorado	1,149 (10.2)	1,043 (8)
NCH	7,788 (69.3)	9,564 (73)
KP Northwest	1,507 (13.4)	1,626 (12)
Age		
3-12 years	6,514 (58.0)	6,668 (53.5)
13-17 years	4,719 (42.0)	5,792 (46.5)
Gender		
Female	5,428 (48.3)	6,240 (50.1)
Male	5,805 (51.7)	6,220 (49.9)
Race		
White, Non-Hispanic	7,292 (64.9)	8,185 (65.7)
Youth of Color	3,941 (35.1)	4,275 (34.3)
Insurance Type		
Medicaid	3,395 (30.2)	5,641 (45.3)
Commercial	7,838 (69.8)	6,819 (54.7)

[†]Average monthly eligible youth is not equivalent to the number of individuals treated at each of these sites, as youth could be eligible in multiple months and it was an open cohort with youth entering and leaving the population.

[‡]KP Northwest implemented the SUAY intervention one year later than the other three sites, resulting in a different denominator for the post-intervention time period stratified by site.

Abbreviations: KP, Kaiser Permanente; NCH, Nationwide Children's Hospital

Table 2. Interrupted Time Series Analysis of the effect of the Safer Use of Antipsychotics in Youth (SUAY) intervention on antipsychotic initiation rates in all SUAY eligible youth, adjusted for age and insurance, 2013-2020.

Variable	**Coefficient estimate, prescriptions per 10,000 person months**	**95% Confidence Interval**	**Newey-West standard error**	**P-Value**
Intercept	52.44	(46.53, 58.36)	2.88	*0.000*
Pre-intervention slope	-0.73	(-1.16, -0.30)	0.21	*0.002*
Level change in time period immediately following intervention	-6.57	(-12.15, -0.99)	2.72	*0.023*
Difference between pre- and post-intervention slopes	1.09	(0.32, 1.85)	0.37	*0.007*
Post-intervention slope	0.36	(-0.27, 0.99)	0.31	0.255

Figure 1. Rate of antipsychotic initiations per 10,000 person months in the Safer Use of Antipsychotics in Youth (SUAY) eligible population between 2013-2020, not centered on intervention start time period. The red vertical line depicts the approximate start of the SUAY intervention.

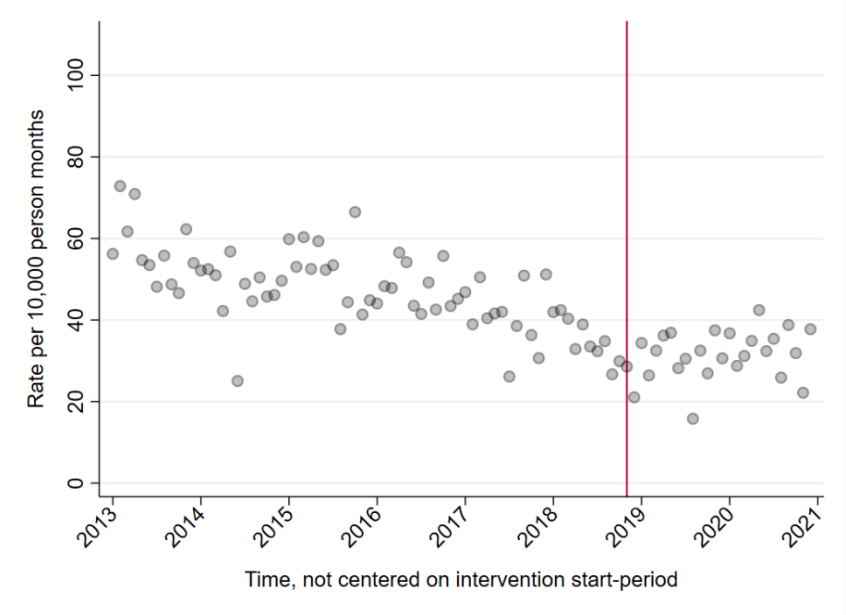


Figure 2. Time series of the rate of antipsychotic initiations per 10,000 person months in the overall Safer Use of Antipsychotics in Youth (SUAY) eligible population, adjusted for age and insurance type. Fitted trend lines show predicted values from the segmented regression analysis, with 95% confidence intervals. The red vertical line depicts the start of the SUAY intervention.

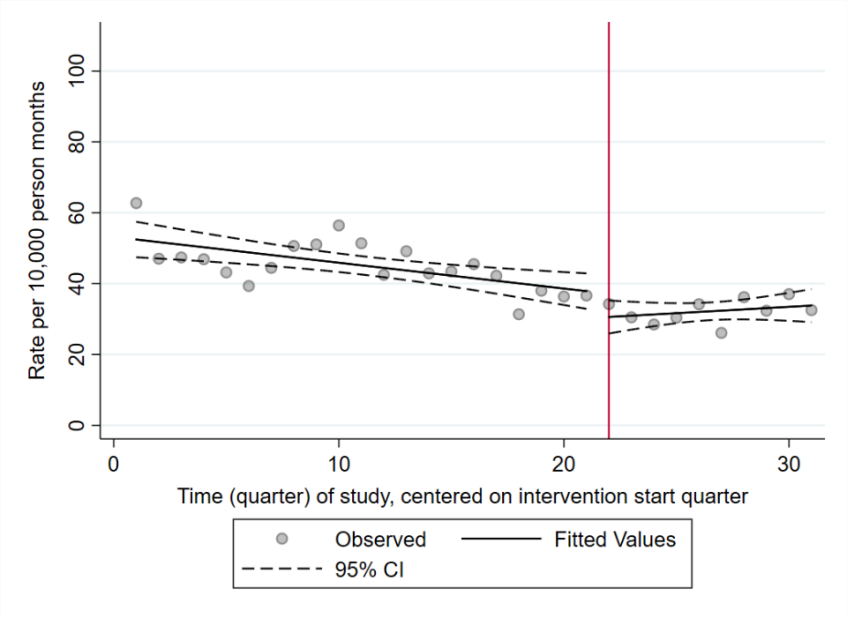
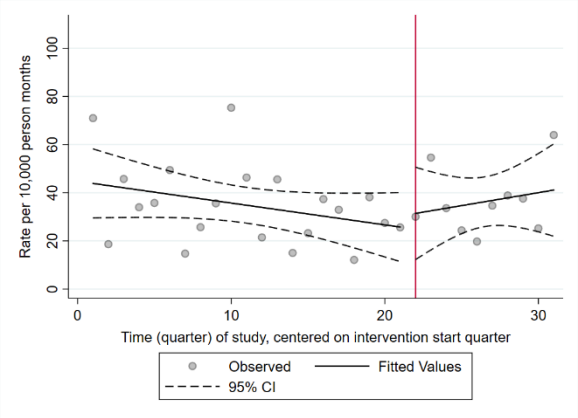
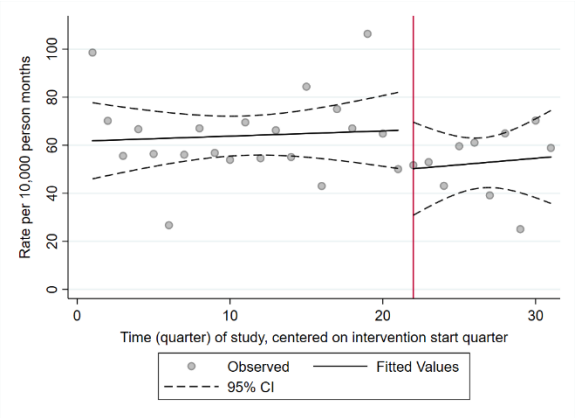


Figure 3. Time series of the rate of antipsychotic initiations per 10,000 person months in the Safer Use of Antipsychotics in Youth (SUAY) eligible population by site. Fitted trend lines show predicted values from the segmented regression analysis, with 95% confidence intervals. The red vertical line depicts the start of the SUAY intervention.

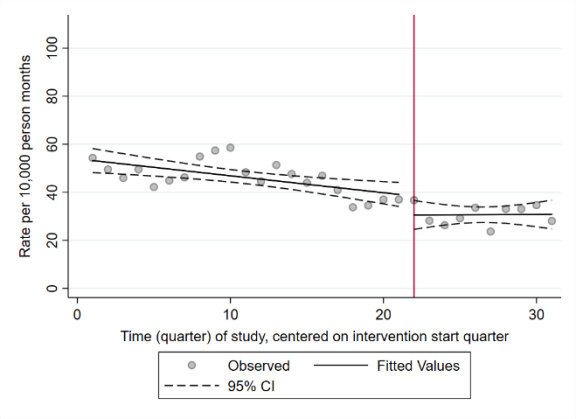
A. KP Washington



B. KP Colorado



C. Nationwide Children's Hospital (NCH)



D. KP Northwest

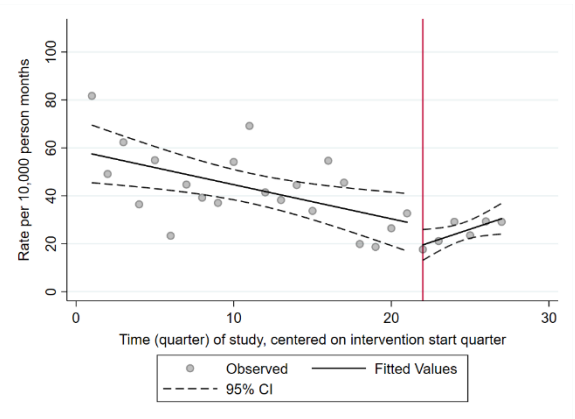
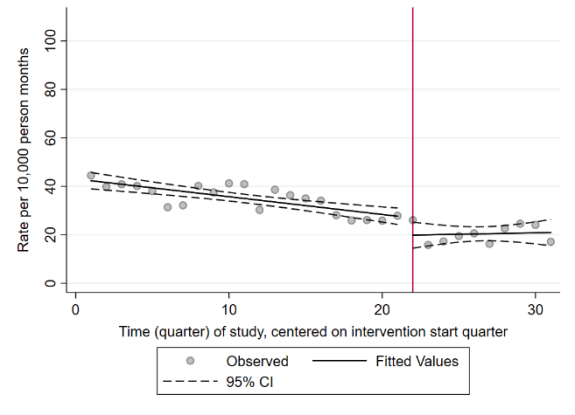


Figure 4. Time series of the rate of antipsychotic initiations per 10,000 person months in the Safer Use of Antipsychotics in Youth (SUAY) eligible population by age. Fitted trend lines show predicted values from the segmented regression analysis, with 95% confidence intervals. The red vertical line depicts the start of the SUAY intervention.

A. Age 3-12



B. Age 13-17

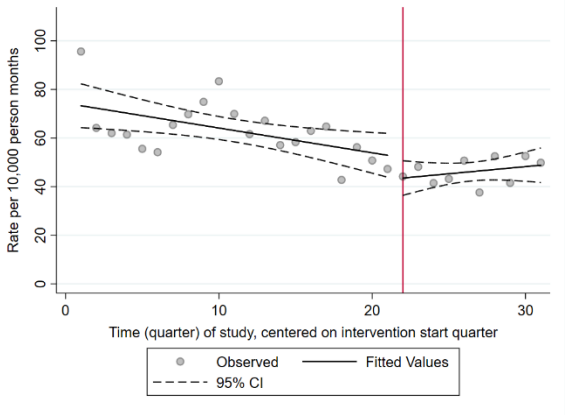
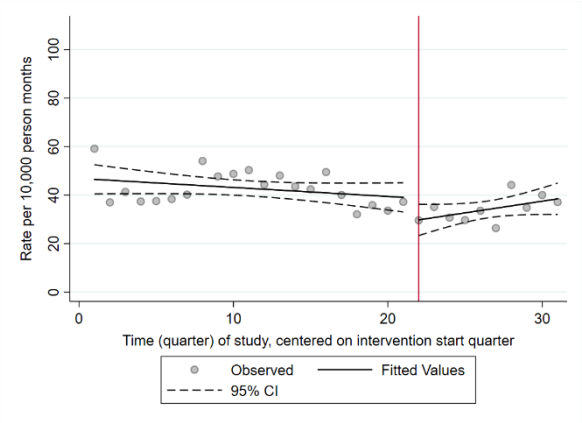


Figure 5. Time series of the rate of antipsychotic initiations per 10,000 person months in the Safer Use of Antipsychotics in Youth (SUAY) eligible population by gender. Fitted trend lines show predicted values from the segmented regression analysis, with 95% confidence intervals. The red vertical line depicts the start of the SUAY intervention.

A. Females



B. Males

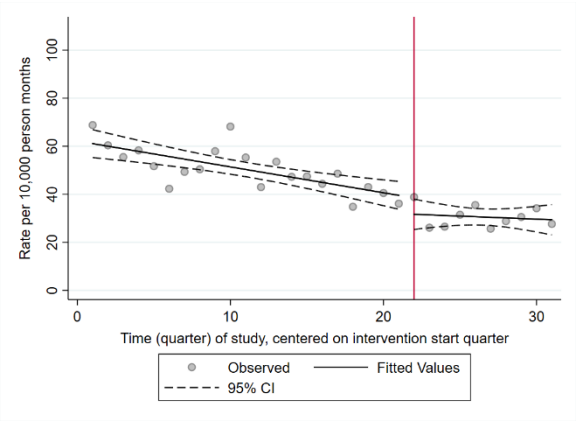
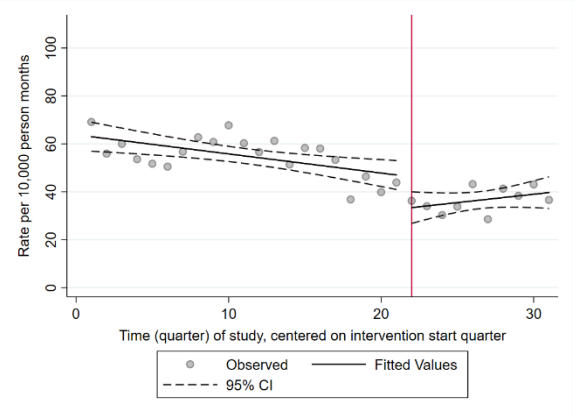


Figure 6. Time series of the rate of antipsychotic initiations per 10,000 person months in the Safer Use of Antipsychotics in Youth (SUAY) eligible population by race. Fitted trend lines show predicted values from the segmented regression analysis, with 95% confidence intervals. The red vertical line depicts the start of the SUAY intervention.

A. White, Non-Hispanic Youth



B. Youth of Color

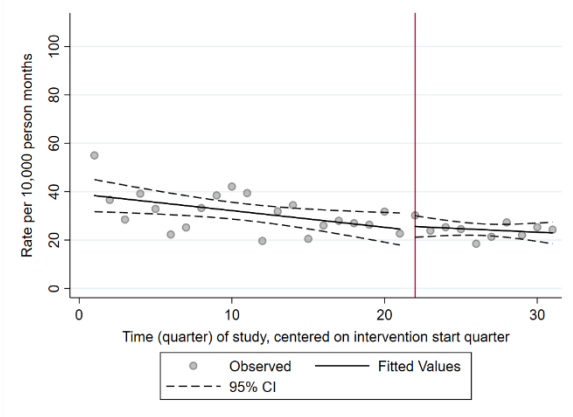
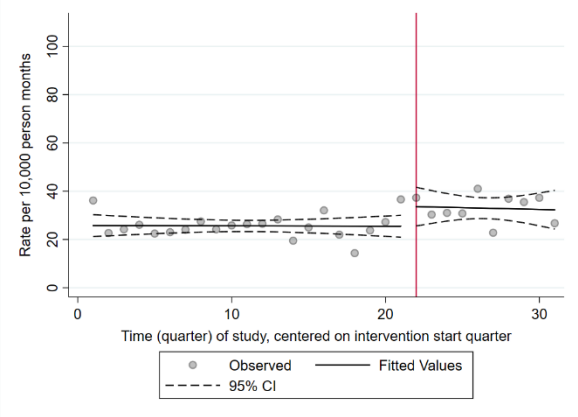
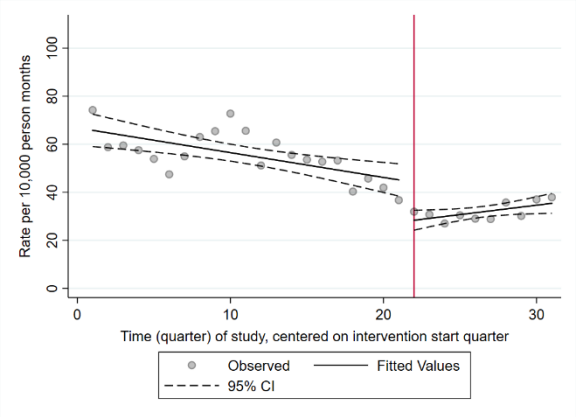


Figure 7. Time series of the rate of antipsychotic initiations per 10,000 person months in the Safer Use of Antipsychotics in Youth (SUAY) eligible population by insurance type. Fitted trend lines show predicted values from the segmented regression analysis, with 95% confidence intervals. The red vertical line depicts the start of the SUAY intervention.

A. Medicaid Insurance



B. Commercial Insurance



Appendix

Table 3. Interrupted Time Series Analysis of the effect of the Safer Use of Antipsychotics in Youth (SUAY) intervention on antipsychotic initiation rates in SUAY eligible youth, stratified by subgroup.

Variable	Coefficient estimate, prescriptions per 10,000 person months	95% Confidence Interval	Newey-West standard error	P-Value
KP Washington				
Intercept	43.86	(27.42, 60.31)	8.01	*0.000*
Pre-intervention slope	-0.91	(-2.07, 0.26)	0.57	0.122
Level change in time period immediately following intervention	6.57	(-14.22, 27.37)	10.13	0.522
Difference between pre- and post-intervention slopes	1.98	(-1.93, 5.89)	1.91	0.307
Post-intervention slope	1.08	(-2.66, 4.81)	1.82	0.559
KP Colorado				
Intercept	61.85	(43.25, 80.45)	9.06	*0.000*
Pre-intervention slope	0.22	(-1.43, 1.87)	0.80	0.791
Level change in time period immediately following intervention‡	-16.16	(-37.33, 5.02)	10.32	0.129
Difference between pre- and post-intervention slopes	0.33	(-2.76, 3.41)	1.50	0.829
Post-intervention slope	0.54	(-2.06, 3.15)	1.27	0.672
NCH†				
Intercept	53.20	(47.50, 58.91)	2.78	*0.000*
Pre-intervention slope	-0.70	(-1.13, -0.27)	0.21	*0.002*
Level change in time period immediately following intervention	-7.83	(-15.70, 0.03)	3.83	0.051
Difference between pre- and post-intervention slopes‡	0.72	(-0.26, 1.70)	0.48	0.143
Post-intervention slope	0.02	(-0.89, 0.93)	0.44	0.969
KP Northwest				
Intercept	57.49	(43.27, 71.70)	6.87	*0.000*
Pre-intervention slope	-1.43	(-2.50, -0.35)	0.52	*0.011*
Level change in time period immediately following intervention	-8.03	(-19.95, 3.90)	5.76	0.177
Difference between pre- and post-intervention slopes	3.61	(2.24, 4.99)	0.66	*0.000*

Variable	Coefficient estimate, prescriptions per 10,000 person months	95% Confidence Interval	Newey-West standard error	P-Value
Post-intervention slope	2.19	(1.33, 3.04)	0.42	*0.000*
Age 3-12				
Intercept	42.31	(39.48, 45.14)	1.38	*0.000*
Pre-intervention slope	-0.73	(-0.94, -0.52)	0.10	*0.000*
Level change in time period immediately following intervention	-7.05	(-13.51, -0.60)	3.15	*0.033*
Difference between pre- and post-intervention slopes	0.85	(-0.23, 1.93)	0.52	0.117
Post-intervention slope	0.12	(-0.94, 1.17)	0.51	0.822
Age 13-17				
Intercept	73.3	(61.44, 85.17)	5.78	*0.000*
Pre-intervention slope	-1.02	(-1.89, -0.15)	0.42	*0.023*
Level change in time period immediately following intervention	-8.35	(-17.32, 0.63)	4.38	0.067
Difference between pre- and post-intervention slopes	1.61	(0.44, 2.78)	0.57	*0.009*
Post-intervention slope	0.59	(-0.19, 1.37)	0.38	0.135
Female				
Intercept	46.50	(38.88, 54.13)	3.72	*0.000*
Pre-intervention slope	-0.37	(-0.95, 0.21)	0.28	0.197
Level change in time period immediately following intervention	-8.92	(-15.62, -2.22)	3.27	*0.011*
Difference between pre- and post-intervention slopes	1.34	(0.48, 2.20)	0.42	*0.004*
Post-intervention slope	0.96	(0.33, 1.60)	0.31	*0.004*
Male				
Intercept	61.09	(55.39, 66.79)	2.78	*0.000*
Pre-intervention slope	-1.08	(-1.47, -0.69)	0.19	*0.000*
Level change in time period immediately following intervention	-6.81	(-15.08, 1.47)	4.03	0.103
Difference between pre- and post-intervention slopes	0.82	(-0.39, 2.03)	0.59	0.174
Post-intervention slope	-0.25	(-1.40, 0.89)	0.56	0.654
White, Non-Hispanic				
Intercept	63.00	(57.25, 68.75)	2.80	*0.000*

Variable	Coefficient estimate, prescriptions per 10,000 person months	95% Confidence Interval	Newey-West standard error	P-Value
Pre-intervention slope	-0.80	(-1.30, -0.30)	0.24	*0.003*
Level change in time period immediately following intervention	-12.82	(-20.58, -5.06)	3.78	*0.002*
Difference between pre- and post-intervention slopes	1.50	(0.61, 2.38)	0.43	*0.002*
Post-intervention slope	0.70	(-0.04, 1.43)	0.36	0.062
Youth of Color				
Intercept	38.36	(29.97, 46.75)	4.09	*0.000*
Pre-intervention slope	-0.69	(-1.29, -0.09)	0.29	*0.026*
Level change in time period immediately following intervention	1.70	(-5.10, 8.51)	3.32	0.612
Difference between pre- and post-intervention slopes	0.39	(-0.49, 1.28)	0.43	0.368
Post-intervention slope	-0.29	(-0.94, 0.35)	0.32	0.360
Medicaid Insurance				
Intercept	25.73	(20.72, 30.73)	2.44	*0.000*
Pre-intervention slope	-0.01	(-0.53, 0.51)	0.25	0.961
Level change in time period immediately following intervention	8.14	(-0.38, 16.66)	4.15	0.060
Difference between pre- and post-intervention slopes	-0.13	(-1.28, 1.02)	0.56	0.816
Post-intervention slope	-0.14	(-1.17, 0.88)	0.50	0.775
Commercial Insurance[†]				
Intercept	65.78	(57.68, 73.88)	3.95	*0.000*
Pre-intervention slope	-1.03	(-1.61, -0.45)	0.28	*0.001*
Level change in time period immediately following intervention	-15.77	(-23.94, -7.59)	3.98	*0.000*
Difference between pre- and post-intervention slopes	1.81	(0.97, 2.66)	0.41	*0.000*
Post-intervention slope	0.78	(0.09, 1.47)	0.34	*0.028*

[†]Accounting for first-order autocorrelation

[‡]Evidence of a competing trend in the pre-intervention time period

Abbreviations: KP, Kaiser Permanente; NCH, Nationwide Children's Hospital