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Evaluation of peer recovery services for substance use disorder in Minnesota

Impact of peer recovery on SUD treatment and recovery

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Executive summary

Substance use disorder (SUD) remains one of the most persistent public health challenges across the nation and in Minnesota. In 2021, nearly 1,300 Minnesotans died of a drug overdose, making this the leading cause of injury deaths in the state. One intervention to help people with SUD is peer recovery services (PRS). PRS is a form on non-clinical support where trained individuals who are more established in recovery come alongside people currently in the recovery journey and provide guidance in the treatment process, help in accessing resources, and offer an empathetic ear. In combination with other services in the continuum of care, PRS seeks to reduce harm from disordered use.

In 2018, Minnesota made PRS for SUD a Medicaid (MA)-reimbursable service. While prior literature demonstrates promising effects of PRS for SUD, especially in treatment retention and participant experience, most studies evaluated PRS in limited settings, rather than in a large-scale implementation.

Our study estimated the causal impact of MA-reimbursable PRS for SUD on treatment, overdose, mortality, access to care, housing, and child welfare. We used administrative data to compare outcomes for people who participated in PRS through MA with similar eligible SUD patients who did not use PRS, over the course of a year. Overall, we found evidence of a system that may not be fully built; PRS leads to positive results but has not produced all of the benefits stakeholders expect or desire. In particular:

- Patients with at least one PRS session were more likely to complete outpatient treatment in the follow-up year than comparison patients. At the end of follow-up, PRS patients were 61% (95% confidence interval [CI]: 14%, 127%) more likely to complete outpatient than the comparison group.
- PRS patients were also more likely to visit a physician's office for medical care than comparison patients. In the first quarter of follow-up, 73% (95% CI: 70%, 76%) of PRS patients visited a physician's office compared to just 62% (95% CI: 59%, 66%) of comparison patients. This statistically significant difference was limited to the first quarter of follow-up.
- We found no impact of PRS on diagnosed non-fatal overdose, all-cause mortality, inpatient treatment admission, housing instability, or child welfare maltreatment reports.
- The impact of PRS for patients with sustained participation was similar to the overall impact for all participants.
- We found no differences in the impact of PRS across race, sex, opioid use status, or geography.

While PRS shows promise in improving treatment retention and access to care, we did not find benefits of PRS for other desired outcomes stakeholders identified. We discuss potential reason for this, including the wide variation in PRS delivery and the need for improved training, mentoring, and supports for peers and participants. These evidence-informed lessons have the potential to improve PRS's impact. We end by noting the need for more data collection and further qualitative and quantitative study.

Acknowledgments

We would like to thank numerous partners at the Minnesota Department of Human Services for their time, expertise, and data assistance over the course of this evaluation. Neerja Singh, Dana Nelson, Shelley White, and Jana Nicolaison, along with many others, have been tremendously helpful in all aspects of the project, including the policy landscape, data collection and assistance, and stakeholder connection. We also greatly appreciate the organizations and individuals in the SUD recovery and treatment field that generously gave their time and knowledge to help us understand the service better. Thanks also to the other agency partners at the Department of Health and the MN Courts for assistance with data and other components. Finally, we thank our teammates at MMB, Laura Kramer, Anna Solmeyer, Ian Williamson, and Anita Alur for their instrumental help in this project.

About the team

MMB's Impact Evaluation unit is a team of data and social scientists that rigorously evaluates state investments and policies to find what works and what does not. The legislature established the team in 2019 to assess the impact of the state's response to the opioid epidemic and to study human services grants, broadly. We prioritize working with agencies and partners to identify and answer pressing questions and creating evidence that is rigorous, relevant, and used by policymakers.

For more information or to learn about current and future areas of study, please visit https://osf.io/mzebh/ or contact ResultsFirstMN@state.mn.us.

Introduction

Substance use disorder (SUD) is one of the most widespread and persistent public health challenges facing Minnesota and the United States more broadly. SUD alone has an array of health consequences, and it is closely correlated with other physical and mental illnesses. Estimates from the National Survey on Drug Use and Health (NSDUH) suggest that over 17% of Minnesotan adults ages 18 or older lived with SUD from 2019 to 2020 Minnesota exceeds the national average of 15.4% (*2019-2020 National Survey on Drug Use and Health: Model-Based Prevalence Estimates (50 States and the District of Columbia)*, 2021).

One emerging intervention to aid individuals with SUD is the use of peer recovery services (PRS). PRS uses credentialed peer specialists who are a year or more into SUD recovery to support people currently experiencing SUD or starting their recovery journey through informational, emotional, social, or other types of support. Peer certification is required to include "skills and training in the domains of ethics and boundaries, advocacy, mentoring and education, and recovery and wellness support," as well as ongoing supervision by an alcohol and drug counselor (State of Minnesota Revisor of Statutes, 2021).

Recovery communities across the country have practiced PRS for decades, and it has grown steadily Minnesota since 2010, when the first Recovery Community Organization (RCO) was established. As of June 2022, there were 18 operational RCOs and a host of substance use treatment centers across Minnesota that employed PRS in some fashion. Federal and state sources have awarded PRS around $4 million in grant funding and other appropriations in Minnesota since 2017.

As part of broader SUD systems reform in 2018, the state of Minnesota made PRS reimbursable through Medicaid/Medical Assistance (MA) and the state's Behavioral Health Fund. As of May 2022, MA has reimbursed $6.5 million in PRS claims. Through this systems reform, peer recovery is now billable for Medicaid reimbursement by Certified Peer Recovery Specialists (CPRS), who are supervised under authorized clinicians at eligible vendors (RCOs, 245G-designated treatment providers, and other DHS-recognized eligible providers) at a rate of $15.02 per 15-minute increment for up to 8 units per day. In addition to a provider being an authorized vendor and employing certified peers to bill Medicaid for PRS, clients also have to be financially eligible for Minnesota Health Care Programs, be diagnosed with SUD, complete an in-depth behavioral health assessment, and have risk ratings that support medical necessity for the recommended SUD treatment and services.

Stakeholder engagement

While scoping this project, we met with a variety of stakeholders that used PRS, including representatives from RCOs, licensed 245G treatment centers, tribal recovery organizations, the Minnesota Certification Board, and others in the substance use recovery and treatment landscape. These conversations gave us a broader and deeper understanding of PRS across Minnesota, including how it is used in treatment centers and in the community, desired outcomes, successes and challenges in the workforce and financing, and innovations to best serve patients. A full process evaluation was beyond the scope of this project, but we drew on these conversations, in addition to prior literature, to contextualize our findings.

Current state of evidence for PRS

Literature on the efficacy of PRS for SUD recovery has received growing attention over the past decade. Three systematic reviews from Reif et al. (2014), Bassuk et al. (2016), and Eddie et al. (2019), summarize and assess the quality and findings of the existing evidence.

Two key themes emerge from these three reviews. First, findings indicate that PRS may improve certain outcomes for people with SUD, especially in treatment and access to medical resources. This is evidenced by consistent findings of improved treatment retention and patient satisfaction across methodologically strong studies. Evidence for reductions in substance use, relapse, and hospitalization is more mixed. Some studies find modest improvements in these outcomes, though these studies may not be as rigorous as others reviewed, while other research finds null effects.

Second, the studies surveyed by these systematic reviews vary widely along several dimensions, including the specific populations studied and methodological rigor. Most studies assess PRS implementations in small-scale settings, and many do not use methods that identify the causal impact of the program while accounting for other confounding factors. These reviews also point to the variation in the definitions of peer recovery support. We aimed to build on this body of research by conducting an evaluation of PRS scaled state-wide.

Evaluating the impact of Medicaid-reimbursable PRS in Minnesota

This study sought to examine the impact of Medicaid-reimbursable peer recovery services for people with SUD in Minnesota on a host of relevant outcomes by drawing on a large administrative data set of medical claims and treatment records. We used a retrospective matched-comparison study to determine whether, among adult patients who were enrolled in Medicaid, receiving at least one PRS session (compared to eligible patients who did not receive any PRS sessions) changed the likelihood that the patient:

1. was diagnosed with poisoning by alcohol and/or several common drugs of abuse;
2. died of any cause;
3. was admitted to inpatient treatment;
4. successfully completed outpatient treatment;
5. received medical care in a physician's office visit;
6. experienced housing instability; or
7. had a screened-in child maltreatment report

This study included an intent-to-treat evaluation, in which all patients with at least one PRS claim were compared to patients with no PRS claims. This approach addressed what Eddie et al. (2019) identified as lacking in the existing quasi-experimental literature. It also included a per-protocol design, in which patients with a minimum number of PRS claims were compared to patients with no PRS claims to assess what outcomes might be seen if PRS retention were improved. To our knowledge, this was the first study that uses causal methods to evaluate a statewide PRS program.

We also examined whether these outcomes were significantly different (1) for patients who maintained regular PRS services during the first quarter of follow-up or (2) by racial group, sex, opioid use disorder diagnosis status, and geographic region.

Data and methods

Study design

For this evaluation, we conducted a retrospective matched-cohort study of Medicaid-enrolled substance use disorder (SUD) patients between January 1, 2019 and June 30, 2021. Within this population, we estimated the impact of receiving one or more sessions of peer recovery services on outcomes related to treatment of SUD. We looked at the effect of peer recovery services using a difference-in-differences approach (see appendix B for more on the matching process and statistical analysis).

Data sources

We used administrative data[1] from five sources for this study:

- **Medicaid Management Information System (MMIS):** Peer recovery claims and substance use, general health, Medicaid enrollment, and demographic information
- **Drug and Alcohol Abuse Normative Evaluation System (DAANES):** Substance use treatment history and Rule 25 and Direct Access Comprehensive Assessment risk ratings
- **Social Service Information System (SSIS):** Child welfare maltreatment report records
- **MAXIS:** Housing stability records from public assistance enrollment
- **Minnesota Courts:** Charge, conviction, and sentencing criminal history records

Inclusion criteria

For our analysis, we identified individuals in the administrative dataset that were 18 years of age or older; enrolled in medical assistance (MA), Minnesota's Medicaid program, for at least 3 consecutive months prior to their study enrollment date; had a primary SUD diagnosis (ICD10 codes F10-F19); and had a qualifying score on a Rule 25 assessment. For more information on how many patients met the criteria at each stage, see appendix A.

Outcome measures

Outcome measures were selected in close consultation with DHS and other PRS stakeholders. These included four primary outcomes that were most directly linked to substance use and treatment and have been used in prior research, as well as three exploratory outcomes that were not as well established in the literature but were of interest to our key stakeholders. Outcomes were aggregated into four, three-month follow-up periods after study enrollment.

Table 1. Primary outcomes

Outcome	Coding values
Non-fatal overdose	1 = has one or more ICD-10 non-fatal overdose code[a]

[1] This study was approved by the Minnesota Department of Human Services Institutional Review Board (IRB # 396). A data sharing agreement between DHS and MMB allows secure sharing between these agencies.

Outcome	Coding values
	0 = has zero ICD-10 non-fatal overdose
All-cause mortality	1 = is deceased during or prior to quarter 0 = is not deceased
Admission to inpatient SUD treatment	1 = admitted to inpatient SUD treatment (cumulative after index date) 0 = no admission to inpatient SUD treatment
Completion of licensed outpatient SUD treatment	1 = completion of licensed outpatient SUD treatment (cumulative after index date) 0 = no completion of licensed outpatient SUD treatment

[a] ICD-10 non-fatal overdose codes include T40.0 – T40.4 and T40.6 (any opioid), T40.5 and T43.6 (any stimulant), T42.3 (barbiturate), T42.4 (benzodiazepine), T42.6 (antiepileptic/sedative-hypnotic), T40.7 (cannabis), T40.8 and T40.9 (any hallucinogen), T51.0 (ethanol) and T51.9 (unspecified alcohol).

Table 2. Exploratory outcomes

Outcome	Coding values
Screened-in child welfare maltreatment report	1 = report on file 0 = no report
Housing instability	1 = unstable housing during the follow-up period 0 = no reported unstable housing status during the follow-up period
Physician office visit	1 = has one or more physician office visits 0 = has zero physician office visits

Exploratory per-protocol analysis

The main analysis of this report estimated the effect of having at least one PRS session. However, most of those who started PRS did not continue to regularly use the service following their initial claim. Therefore, to identify the effect that would have been observed if all individuals in the PRS-exposed population had continued regular PRS treatment, we conducted an exploratory per-protocol analysis (Robins & Hernán, 2020). A per-protocol analysis compares outcomes among the population who did not deviate from their assigned treatment (i.e. the treated population that continued using PRS throughout the first quarter of follow-up compared with the untreated population). For our study, the per-protocol analysis reported the expected outcomes that could be observed if everyone who started PRS continued to participate in the program. This estimate is also useful to patients who wish to know what their expected effect could be if they continue to use PRS.

For the purposes of this analysis, we worked with subject matter experts and the prior literature to define an appropriate minimum "dosage." We defined this as:

- Three consecutive months in the first quarter with at least one service date per month, OR
- Six or more distinct service dates in the first quarter, OR
- Admission to inpatient treatment in the first quarter following the initial PRS claim

Exploratory subgroup analysis

In addition to understanding the effect of PRS for patients with more sustained participation in the per-protocol analysis described above, we were also interested in assessing whether or not the impact of PRS differed by race, sex, opioid use disorder (OUD) status, and geographic area.

Results

Primary outcomes

Figure 1: Main outcomes among PRS participants and comparison patients in a propensity-score-matched cohort

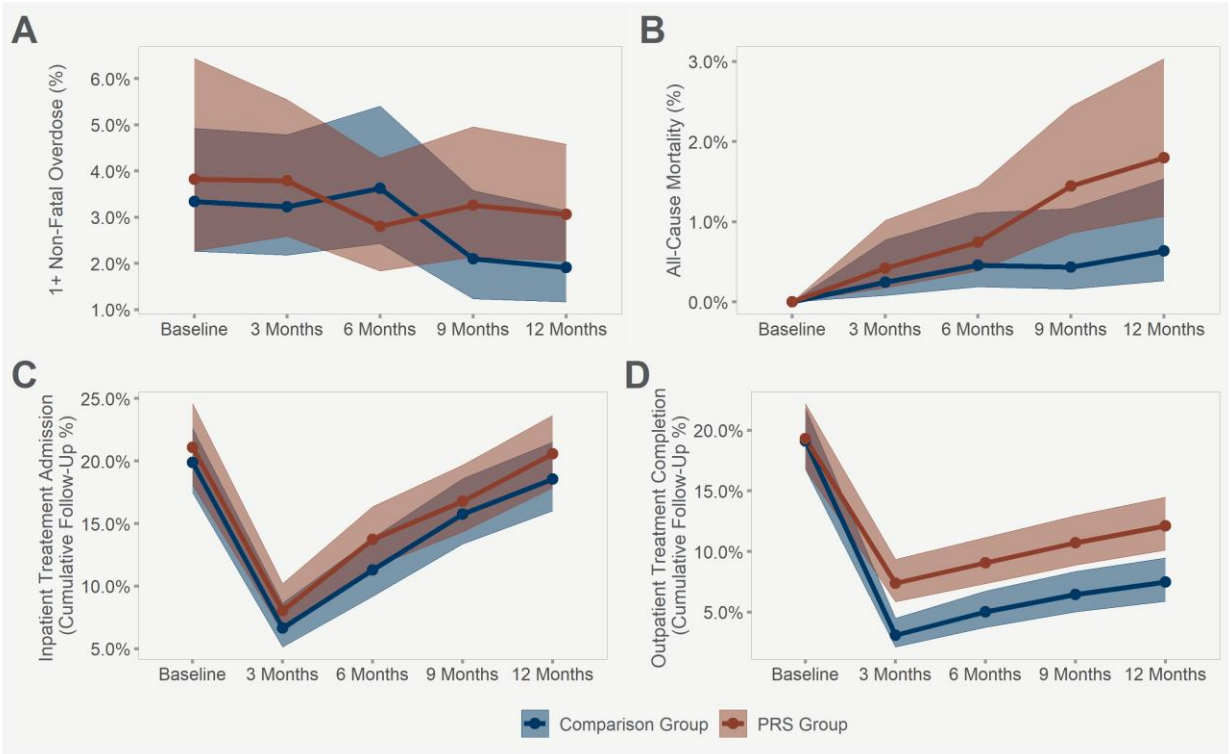


Figure 1 shows models comparing SUD severity and treatment outcomes for PRS patients against comparison patients. Panel A shows the share of patients experiencing at least one non-fatal overdose, and there were no significant differences in outcomes between PRS and comparison patients (overall P = 0.25). In the first quarter of follow-up, 3.8 percent of PRS patients had a non-fatal overdose (95% CI: 2.6%, 5.5%), compared to 3.2 percent of the comparison group (95% CI: 2.2%, 4.8%). Both groups' likelihood of non-fatal overdose fell, with somewhat divergent, but not significantly different,

trajectories, by the fourth quarter of follow-up to 3.1 percent for the PRS group (95% CI: 2.0%, 4.6%) and 1.9 percent for the comparison group (95% CI: 1.2%, 3.1%).

The model in panel B examines changes in mortality from any cause over time. Baseline mortality was, by default, 0 for both groups. While PRS patients were slightly more likely to suffer mortality in the follow-up period, the differences between groups were not significant, either overall (overall P = 0.63) or in any individual quarter. In the first quarter of follow-up, roughly 0.4 percent of PRS patients died (95% CI: 0.2%, 1.0%), compared to 0.2 percent of non-PRS patients (95% CI: 0. 1%, 0.8%). By the fourth quarter of follow-up, a cumulative 1.8 percent of PRS patients suffered mortality (95% CI: 1.1%, 3.0%), relative to 0.6 percent of non-PRS patients (95% CI: 0.3%, 1.5%).

The plot in panel C shows no significant differences in inpatient treatment admission for PRS patients compared to the non-PRS group, either overall (overall P = 0.38) or in any individual quarter. In the first quarter of follow-up, 8.1 percent of PRS individuals were admitted to inpatient treatment (95% CI: 6.3%, 10.2%), compared to 6.7 percent of non-PRS individuals (95% CI: 5.1%, 8.6%). In the fourth quarter, the cumulative share of PRS patients admitted to inpatient treatment increased to 20.6 percent (95% CI: 17.9%, 23.7%), relative to 18.6 percent of non-PRS patients (95% CI: 16.0%, 21.5%).

Panel D shows the probability of a patient completing outpatient treatment. In all four follow-up quarters, the PRS group had a statistically significantly greater probability of completing outpatient treatment, relative to the comparison group (overall P = 0.01). In the first quarter post-baseline, 7.4 percent of PRS patients (95% CI: 5.9%, 9.3%) completed outpatient treatment, compared to 3.1 percent of non-PRS patients (95% CI: 2.1%, 4.5%). We estimated that PRS patients were 137% more likely (95% CI: 48%, 280%) to complete outpatient treatment than comparison patients in the first quarter. The probability of outpatient treatment completion remained higher for the PRS group throughout the full year of follow-up; after 12 months, PRS participants were 61 percent more likely to complete outpatient treatment than the comparison group (95% CI: 14%, 127%).

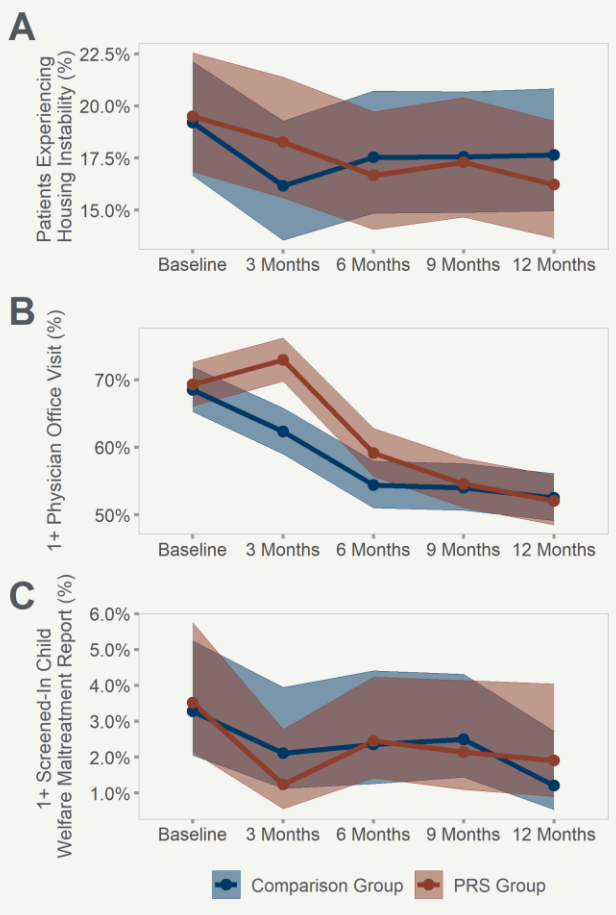
Exploratory outcomes

Figure 2 shows results from analyses of exploratory outcomes. Panel A examines housing instability for the PRS and comparison groups and shows that there were no significant differences between the groups, either overall or in any individual follow-up quarter (overall P = 0.34). PRS participants had an 18.3 percent probability of experiencing housing instability in the first three months of follow-up (95% CI: 15.6%, 21.4%), and comparison patients had a 16.2 percent probability (95% CI: 13.6%, 19.3%). Though both groups' probability decreased over time, PRS patients were less likely than comparison patients to experience housing instability by the fourth quarter (Relative risk (RR): -9%; 95% CI: -30%, 18%). These differences were not statistically significant.

Panel B shows that PRS patients were more likely to have health care visits than patients in the comparison group (overall P < 0.001). This difference was concentrated to the first quarter of follow-up, when 73 percent of PRS patients had a visit to a general or specialty health care physician (95% CI: 69.8%, 76.2%), while only 62.3 percent of patients in the comparison group did (95% CI: 59.0%, 65.8%). This corresponds to an estimated 16 percent higher probability for the PRS group (95% CI: 7%, 26%). However, PRS initiators did not have a higher probability of visiting a medical office in subsequent periods, during which 50 to 60 percent of both PRS and comparison patients had physician office visits (95% CI: -12%, 9%).

Panel C assesses differences in the probability of having a screened-in child welfare maltreatment report among individuals with dependent children. Overall, PRS patients did not have a statistically significantly lower probability of having a screened-in child welfare maltreatment report (overall P = 0.75). In the first quarter, PRS patients did have a 45 percent lower risk of being screened in (95% CI: -83%, 75%) than the comparison group, though the difference was not statistically significant. In that period, 1.2 percent of PRS patients had a screened-in maltreatment report (95% CI: 0.6%, 2.8%), relative to 2.1 percent of comparison patients (95% CI: 1.1%, 3.9%).

Figure 2: Exploratory outcomes among PRS participants and comparison patients in a propensity-score-matched cohort



Per-protocol analysis

Description of Per-Protocol Analysis

The per-protocol analysis estimated the effects of participating in PRS that would have been observed if the entire PRS population completed the minimum specified amount of PRS services. Table 2 in appendix A includes the baseline characteristics of PRS participants who had at least 3 consecutive months with PRS claims, or at least 6 claims in the first 3 months, compared to PRS initiators who did not meet that criteria. Of 1,227 PRS participants in the overall sample, 266 (21.7%) met at least one of the two definitions of minimum exposure.

PRS patients who met the minimum dosage or per-protocol threshold were more likely to:

- **Be female** (48.1% of per-protocol versus 36.2% of non-per protocol patients, *P* < .001)
- **Have children** (57.5% of per-protocol versus 51.4% of non-per protocol patients, *P* = .017); in particular, female patients with children were more represented (32.4% versus 20.8%, *P* < .001).
- **Live in Greater Minnesota** (45.9% versus 33.2%, *P* < .001).
- **Have severe or severe and persistent mental illness** (66.5%, versus 57.9%, *P* = .021).
- **Have had a screened-in child maltreatment report in the baseline period** (4.5% versus 1.1%, *P* < .001)

However, this group was also less likely to have had a nonfatal overdose (1.1% versus 4.1%, *P* = .033).

In the first quarter of follow-up before applying weights, the per-protocol patients were significantly less likely to have been admitted to inpatient treatment (3.8%, versus 9.7% of non-per-protocol patients, *P* = .003). Per-protocol patients were also more likely to have had a physician office visit (80.5%, versus 70.4% of non-per-protocol patients, *P* = .0016).[2]

Per-Protocol Effect Estimates

Figure 3 shows the results of the main outcomes hypothesized to be affected by PRS participation. Panel A shows the frequency of drug overdoses. The rate of nonfatal overdoses was relatively steady in the comparison population, falling from 3.4 percent (95% CI: 2.3%, 5.0%) at baseline to 1.9 percent (95% CI: 1.2%, 3.1%) 12 months after baseline. Among PRS patients, nonfatal overdoses declined from 3.2 percent (95% CI: 0.9%, 10.6%) at baseline to 0.3 percent at 6 months (95% CI: 0.1%, 1.3%), but rebounded to 2.6 percent at 12 months (95% CI: 0.8%, 8.1%). While the change in risk of nonfatal overdose was statistically significant overall (P = .011) and was notably different at the 6-month mark, there was not a consistent pattern of reduction through the follow-up period.

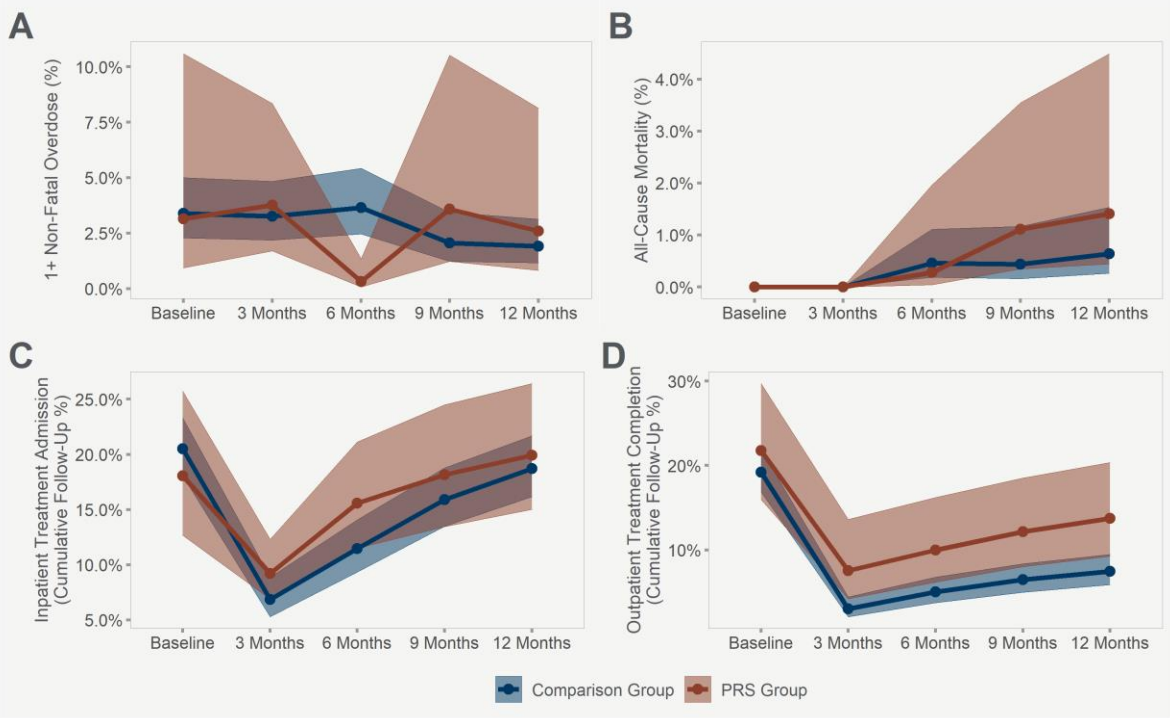
Panel B shows that no significant differences in mortality were observed between the groups (overall *P* = .34). Among the PRS population, 1.4 percent (95% CI: 0.4%, 4.5%) deceased within 12 months of baseline, compared to 0.6 percent (95% CI: 0.3%, 1.5%) of comparison patients. Due to the rarity of these events and the weights of the people who died, the relative risk of death has very wide confidence bounds; at the fourth quarter, we estimated a 122 percent increased risk of death, with 95 percent confidence limits extending from 48 percent lower risk of death to 847 percent higher risk of death.

Panel C and D show slightly increased probabilities of inpatient treatment admission (overall *P* = .20), and meaningfully increased probabilities of outpatient treatment completion (overall *P* = .26) among PRS patients, though each has a wide confidence interval, and neither is statistically significant. PRS patients were 54 percent (95% CI: -10%, 162%) more likely to be admitted to inpatient treatment within the first quarter following baseline, but that increase faded one year after baseline (21% more likely; 95% CI: -26%, 99%). By comparison, PRS patients were 119 percent (95% CI: 9%, 340%) more likely to complete outpatient treatment within three months of baseline and 62 percent more likely to have

[2] We applied treatment and censoring weights to restrict to per-protocol patients with complete follow-up (226 PRS patients and 853 comparison patients) and to standardize the per-protocol patients to the overall population means at baseline and in the first quarter of follow-up. These weights had a mean of 1.00 (range: 0.155 to 10.6), which we truncated at the 1st and 99th percentiles to reduce the influence of extreme weights.

completed outpatient treatment within a year of baseline (95% CI: -1%, 166%). For other exploratory findings, see Appendix E.

Figure 3. Main results of per-protocol analysis of Peer Recovery Services utilization in a propensity score-matched cohort. Per-protocol utilization defined as all months of first quarter with at least 1 claim, 6+ claims total in first quarter, or admission to licensed substance use disorder inpatient treatment program



Subgroup analysis

Given disparities in the impact of SUD in Minnesota, we expected to find important differences in the effect of PRS by subgroup. Unexpectedly, we found no major differences across the subgroups we analyzed (race, geography, sex, and OUD diagnoses). For full results, see Appendix F.

Discussion and conclusion

Results overview

Overall, we found that Medicaid-reimbursed peer recovery services for SUD patients had a small impact on the use of health care services and no impact on longer-term, more discrete measures of wellbeing. PRS participants had a higher probability of completing outpatient treatment and visiting a physician's office and a lower probability of having a screened-in child maltreatment report. We found no statistically significant differences in the likelihood of non-fatal overdose, mortality, inpatient treatment admission, or housing instability for PRS participants, relative to similarly situated comparison patients in the year after starting PRS. When we assessed outcomes for patients with more sustained participation in PRS, we found similar impacts on outpatient treatment completion and physician office visits, as well as a one-time reduction in the likelihood of non-fatal overdose; but overall, those who

participated longer had similar impacts to the entire population of PRS patients. These findings were largely consistent across racial groups, sex, opioid use disorder status, and geography.

These results of PRS delivered at scale are important, but modest, and largely consistent with prior research on PRS-like programs. These similar programs reported increased treatment admission and retention, but they had small to null effects on drug and alcohol use (Bassuk et al. 2016; Eddie et al. 2019; Reif et al. 2014). In our study, stakeholders revealed their broader goals for PRS, such as reducing SUD severity, subsequent inpatient treatment admissions, housing instability, and child welfare reports. Currently, we find no evidence that these outcomes have been achieved by the current program. Below, we discuss our understanding of these results, the limitations of our analysis, and what existing evidence tells us about how to improve the quality of future PRS services.

Discussion of results

Stakeholder interviews revealed that a large share of organizations use peers to help patients find and maintain appropriate treatment programs, navigating what can be a complex continuum of care for SUD. Therefore, it is heartening to see that PRS participants were more likely to complete outpatient treatment and obtain general medical care, at least in the first few months after beginning PRS.

While the beneficial impacts should not be discounted, it is important to put them in context. The positive effects were short-lived, often contained to one quarter of follow-up, and modest in magnitude. Moreover, in this analysis, we did not see positive impacts on outcomes more closely related to SUD severity and overall wellbeing. PRS participants were no less likely to have unstable housing, have a child welfare report, be admitted to inpatient treatment, have a diagnosed non-fatal overdose, or die during the follow-up period than comparison patients. While our analysis could not determine the exact cause for these results, it did give us hints as to why PRS did not have more of an impact during our study period.

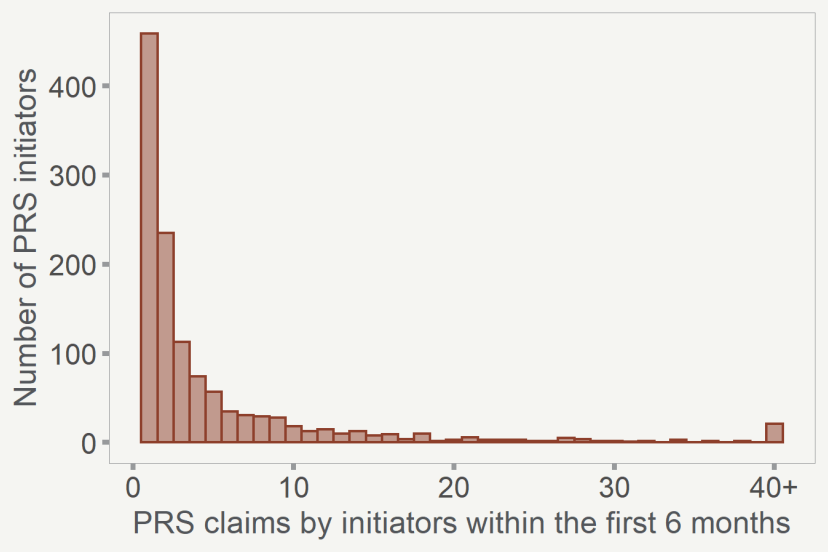
The first potential explanation is participants did not sustain PRS long enough for the service to have its intended effect. As we outlined in the descriptive results, only 20 percent of PRS participants in our sample had six or more claims in total or in the three consecutive months following initiation, which was the minimum dose specified by practitioners. In fact, as figure 4 shows, half of patients had only one PRS claim. This may have limited the extent to which peers could connect with patients and form therapeutic alliances, which practitioners agree—and research shows—is key to success for PRS.

That said, insufficient dose cannot fully explain the lack of impact. We conducted an exploratory analysis on PRS patients with sustained participation. For those clients, there was slightly larger increase in outpatient treatment completion and health care visits and decreases in child welfare involvement and diagnosed non-fatal overdose observed in a single quarter. These benefits are, however, still time-limited and only demonstrate marginal improvement relative to the effect for all PRS initiators.[3] It may

[3] We originally intended to study patients who had PRS claims in 6 consecutive months; however, less than 5% of PRS initiators received this level of continuous treatment.

be that peer recovery alone cannot produce meaningful gains for these outcomes. However, the vast majority of practitioners interviewed believe PRS can play a significant role.

Figure 4: Histogram showing the number of PRS claims by PRS patients within the first 6 months of participation



Another way to think about the issue of sustained participation is that people may not have continued with PRS because it was not effective in meeting their needs for some reason. If this is the case, there may be factors that explain why people are not participating in PRS for longer and why we may not be seeing the desired impact in the population more generally.

One potential hypothesis for these results is that PRS providers may have faced difficulties in building therapeutic alliances with patients. Many organizations are new to PRS and may be working through how to properly match patients to peers. Stakeholders also noted that the peer workforce is relatively small and that many treatment providers and RCOs across the state may have trouble finding a trained peer that may be good match based on the lived experience of the patient. This may lead to peers and patients not developing the strong bonds necessary for PRS to be effective.

Additionally, stakeholders indicated that organizations billing for PRS may not have had the financial resources to properly support their peer workforce. Medicaid reimbursement only covers costs during the period when peers actively work with patients, leaving providers to cover the other costs of employing, supporting, mentoring, and otherwise retaining peers. This could mean that providers only have the resources to hire a small number of peers to work with their patients, and peers do not have the capacity to adequately connect with all of them, or providers cannot provide the necessary training and mentoring (initial and ongoing) that peers need to deliver the best version of the program.

There may also be considerable variation in the content and quality of peer training programs. While all peers must be certified and complete training with an approved vendor following an approved curriculum, there are numerous organizations and curricula supported by the state's certifying body. This means that peers across, and potentially within, organizations may use different approaches while

interacting with patients. Multiple interviewed recovery and treatment stakeholders echoed these concerns and pointed to the need for a more cohesive system of training and standardized curriculum.

Another factor that may have influenced the effectiveness of PRS is the nature and quality of the services available to the comparison group. One strength of our study is the assessment of PRS in a real-world setting, in which patients could select from all available treatments. If the services that the comparison patients accessed, such as 12-step programs, individual and family support groups, grant-funded PRS, or other similar interventions, were similar in efficacy to PRS, we would not see strong results in favor of PRS because the business-as-usual programs were equally as effective. In other words, both groups were improving at similar rates.

PRS is still a relatively new program. Developing a new statewide system of benefits that integrates well-established principles and practices and spans sectors and organizational models takes years of intentional investment and planning. It will likely take more time and resources to maximize the benefits of PRS. It may be appropriate to conduct a new evaluation when those supports have been established.

Limitations

To our knowledge this is the first evaluation of PRS as a statewide program, but it is not without its limitations. First, our study is retrospective and observational, and patients self-selected their treatment. We chose our methods to identify a comparison population as similar as possible to the PRS participants, but as with all observational studies, a causal interpretation rests on the untestable assumption that there are no unmeasured confounding variables.[4]

A second limitation is that we used administrative data as proxies for our outcomes. These data were collected for reporting and financial purposes rather than research, and as such, they may not have perfectly mirrored the variables we were trying to capture. For example, we could identify patients that received treatment for a drug overdose in an emergency room or hospital but could not identify overdoses during which individuals did not seek formal care. We also cannot look at directly at alcohol and drug consumption or abstinence because it is not a consistently collected in administrative data.

Another limitation is the lack of data on comparable peer recovery services covered by funding sources other than Medicaid. Over $4 million in grants have been awarded to recovery and treatment organizations to use PRS in the last five years. We only had data on PRS reimbursed by Medicaid, though there were many patients receiving similar services through other funding sources. We were unable to capture the impact of services covered by different funding and could not determine whether Medicaid-reimbursable PRS had the same effect as PRS funded by other sources. Since there is no data collected on these patients, we do not know if they are the same, better, or worse off than those who receive Medicaid-reimbursable PRS.

Additionally, we did not have qualitative data to explore why PRS is having the impacts it is, or that may explain the lack of impact on most outcomes. Our interviews with stakeholders helped us deduce some

[4] The only way to resolve this issue is to implement PRS as a randomized control trial, which would be highly inappropriate because it would limit access to eligible individuals.

possible explanations, but a detailed process evaluation would provide valuable information to understand the underlying causes of these results.

Lastly, the final sample sizes of the per-protocol analysis and subgroup analyses were relatively small. Due to the low probability of sustaining services for even three months, the per-protocol sample of PRS patients was approximately 1/6th the size of the original sample. Similarly, we would have liked to do more detailed analysis of the impact of PRS for various racial and ethnic populations and by different drug use types, but these groups were too small to draw robust conclusions. While this is a real-world feature of Medicaid-funded PRS that is important to understand, this low sample size decreased the probability of detecting a statistically significant effect of PRS exposure.

Evidence-informed policy and practice implications

Our findings demonstrated that PRS, as it currently operates, is helpful for keeping clients engaged in outpatient treatment and increasing access to healthcare, but it does not appear to affect several other key outcomes identified by stakeholders as goals of the service. PRS may have the potential to influence these outcomes, but changes in policy and practice could be necessary to achieve these goals. We outline potential ways to move forward with Medicaid-funded PRS that are grounded in our findings, prior literature, and practitioner interviews.

A potential policy response would be to create more reliable and sustainable sources of funding that cover the non-billable aspects of peer recovery services, including employment expenses, training and education, and infrastructure building. One of the potential reasons for the limited impact is the lack of resources for employers to support and expand their peer workforce. These expenses cannot be billed to Medicaid, and many providers may not have sufficient resources to cover them. In many cases, peers must pay for the cost of training and certification themselves. Recent research echoes these concerns and points to the need for sustainable, cohesive funding of peer supports across a variety of settings (Chapman et al., 2018; Myrick & del Vecchio, 2016; Stack et al., 2022). Creating sustainable funding, either through long-term grants or rates that cover operational overhead, may increase providers' ability to effectively deploy PRS.

Other changes could focus on standardizing training curriculum for peers. While a variety of curriculums offers choice, it could lead to a fractured system with no common protocol for peers to interact with and aid patients. Choosing or developing one curriculum that can be adapted to different settings for distinctive cultural communities may help standardize how peers work with patients. Practitioners have described the need for training that is ongoing, incorporates real-world practicums, and above all, centers the importance of therapeutic alliance. A range of literature demonstrates the critical role that therapeutic alliance plays broadly in behavioral health services, and substance use in particular (Horvath et al., 2011; Martin et al., 2000). Organizations should make a substantial effort to strengthen therapeutic alliances through training curriculum, continued education, mentoring, and other means. One other impactful way to do this is to work towards increasing diversity in the peer workforce and racial concordance among patients. Having a clinician with similar demographics and/or lived experience has been shown to increase patients' use of preventive medicine (Alsan et al., 2019), as well as improve treatment retention for substance-using youth (Wintersteen et al., 2005).

Relatedly, another option would be to prioritize the broader infrastructure development for PRS in Minnesota. Scholars have highlighted the need to build the peer workforce and related support system for years, and practitioners in recovery and treatment organizations echo the same sentiment (Chapman et al., 2018; Laudet & Humphreys, 2013; Stack et al., 2022). Investing in making training and certification more accessible for aspiring peers, increasing employers' capacity to expand mentoring and associated supports, and building out community resources for people in and seeking recovery would ensure a proper support system for peers and patients and may improve outcomes for individuals with SUD. Building out the density of PRS across the state, especially Greater Minnesota, is critical to reach all people who could benefit from it.

Our last evidence-informed, best practice is to improve data collection for patients receiving peer services covered by other sources. Medicaid funding only covers a select segment of SUD patients who seek peer recovery at recovery organizations or treatment providers. To understand the efficacy of real-world PRS in Minnesota, we need to have more visibility into outcomes for clients covered by grant funding and other sources. Many organizations choose not to bill Medicaid because of the administrative hassle or red tape, especially when they have other available funding. This concern is borne out of both interviews with recovery and treatment organizations and prior research (Stack et al., 2022). Creating incentives to switch from grant funds to Medicaid-reimbursable services pay for PRS, when possible, would allow us monitor participants' outcomes, improving policy and practice. It is also in the state's financial interest to do so, as the federal government covers a portion of Medicaid-reimbursable services, and finite grant dollars currently could be redirected to other needs, like or serving individuals without insurance or improving the infrastructure for peers and participants.

Conclusion

Our study is consistent with the small body of prior research that has reported the potential for peer recovery services to benefit individuals with substance use disorder. We found that SUD patients who used Medicaid-funded PRS were more likely to complete outpatient treatment and medical office visits than those who did not use PRS. There were, however, no significant differences in other outcomes that stakeholders identified as actual or potential targets of the service: mortality, drug overdose, admission to inpatient treatment, or stable housing. Ultimately, Medicaid-reimbursable PRS in Minnesota is helpful across some measures, but our results indicate the system could be improved with several policy and program changes.

Research suggests standardizing training, investing in providers' capacity to provide ongoing education and support for peers, strengthening mentoring and supervision practices, and improving data collection are all avenues to realize the full promise of peer recovery for substance use disorder in Minnesota. Peers are an important part of the continuum of care for people with SUD. Investing in them could help create a path to recovery for all Minnesotans struggling with substance use.

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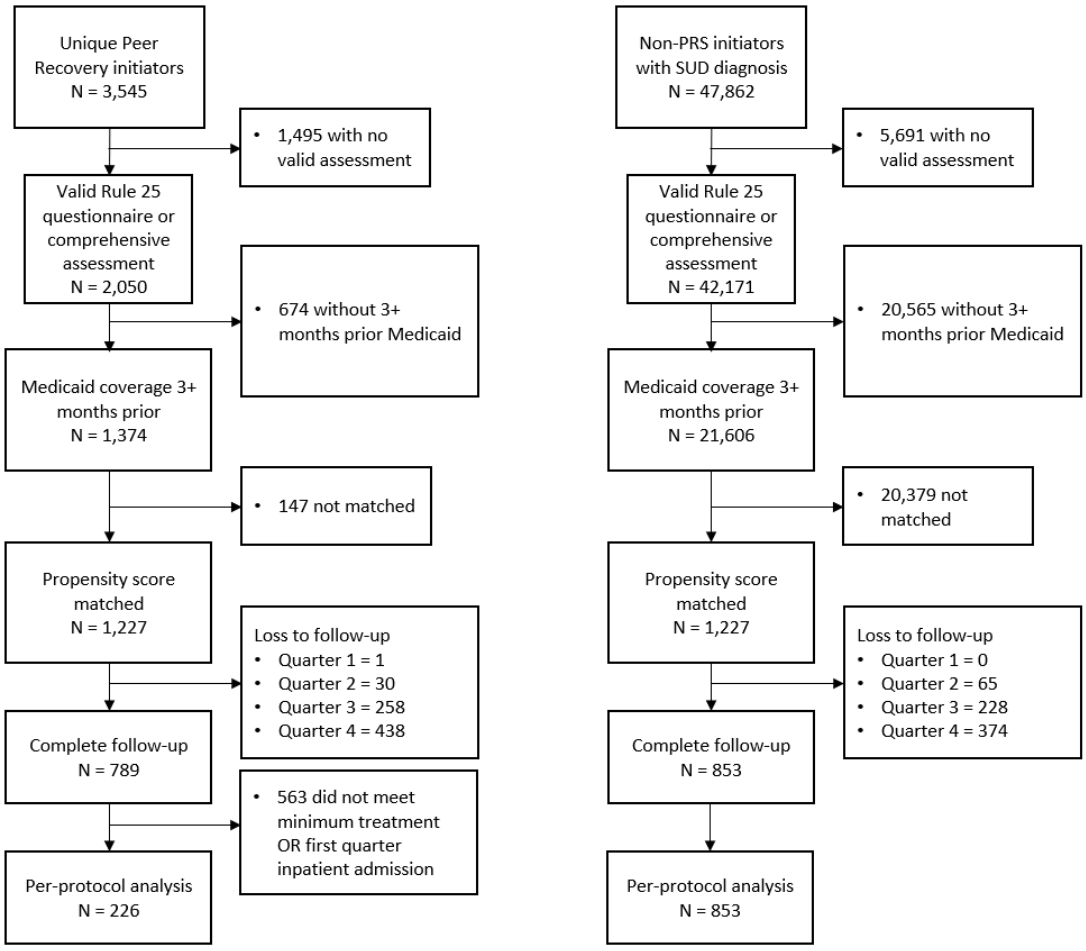
Appendices

Appendix A: Participant inclusion

Figure A1: Participant inclusion and sample size flow diagram



Appendix B: Matching, weighting, and censoring

To recover an unbiased estimate of the impact of peer recovery services, we compared individuals exposed to PRS with unexposed individuals who were as similar as possible on relevant substance use history and demographic factors prior to exposure to PRS. We also ensured that trends in the outcome measures of interest prior to PRS exposure were the same for exposed and unexposed participants.

To create a well-defined comparison group for PRS-exposed individuals, we performed a two-stage process of propensity score matching, followed by adjustment via inverse probability of treatment weighting (IPTW) and inverse probability of censoring weighting (IPCW). To perform this matching and adjusting, we used data on participants obtained during a baseline period prior to their study index date. We aggregated different baseline measures either individually in each of the three months preceding a

participant's index date, during the year prior to the participants index date, or at any point prior to the participant's index date (see Table 1).

We performed matching by first estimating the "propensity-to-treat" for each participant, which used the variables measured and aggregated within the baseline period. The variables included in the propensity score model are presented in Table 1.

Table A1. Variables used in propensity score matching

Variable	Source	Time period
Age group	MMIS	Enrollment date
Sex	MMIS	Current value in data
Region of residence	MMIS	Current value in data
Race	MMIS	Current value in data
Marital status	MMIS	Current value in data
Number of minor children	DAANES	Most recent treatment admission before index date
Past ICD-10 SUD diagnosis: alcohol, cannabis, opioid, cocaine/other stimulant, other	MMIS	Post-October 1, 2015
Rule 25/Comprehensive assessment risk rating: dimensions A, B, C, D, E, F	MMIS, DAANES	Most recent Rule 25 assessment or comprehensive assessment before index date
Date of first ICD-10 SUD diagnosis	MMIS	Post-October 1, 2015
Date of first ICD-10 behavioral/mental health diagnosis	MMIS	Post-October 1, 2015
Recent diagnosis of drug poisoning	MMIS	1, 2, and 3 months prior to index date
Past inpatient treatment admission	DAANES	Ever in records; 1, 2, and 3 months prior to index date
Recent inpatient treatment completion	DAANES	1, 2, and 3 months prior to index date
Past outpatient treatment admission	DAANES	Ever in records; 1, 2, and 3 months prior to index date
Recent outpatient treatment completion	DAANES	1, 2, and 3 months prior to index date
Lifetime treatment admissions	DAANES	Most recent treatment admission before index date
Lifetime detox admissions	DAANES	Most recent detox admission before index date

Variable	Source	Time period
Recent screened-in child maltreatment report	SSIS	1, 2, and 3 months prior to index date
Recent physician office visit	MMIS	1, 2, and 3 months prior to index date
Past criminal justice involvement: any charge, felony charge, conviction, felony sentence, prison sentence, confinement, probation	Courts	Ever in records; 1 year prior to index date
Past housing status: No record, unknown or declined, incarcerated, hospital or other service provider, unstable housing	MAXIS	Ever in records; 1 quarter prior to index date
Mental health status: Serious Mental Illness/Serious and Persistent Mental Illness	MMIS	1 year prior to index date

These variables were used to fit a logistic regression model that expressed an individual's probability of being exposed to PRS as a logit based on their baseline characteristics. For each PRS-exposed participant, a comparison individual was selected from the population of Minnesotans who were eligible for PRS, but who were not otherwise exposed to the program. Each comparison individual had to have a predicted probability of being exposed to PRS that fell within 0.2 standard deviations of the matched exposed participant. If no comparison participants met this criterion for an exposed individual, that exposed individual was dropped from the study.

Once the exposed and unexposed participants were identified, we calculated IPTWs for each individual by refitting the same treatment probability model expressed above for the new sample population. Individual propensity scores were converted to stabilized IPTWs Click or tap here to enter text. and used as regression weights in the final outcome models. Under the necessary assumptions, use of IPTWs has been shown to address selection bias in in observational studies (Robins et al., 2000).

Finally, participants were considered "lost-to-follow-up," and thus censored from outcome data, if they lost Medical Assistance eligibility, died, or if their follow-up quarter ended on or after June 30, 2021 (the end of follow-up). Individuals were censored during the time period when these events occurred, and in all following time periods (with the exception of the mortality outcome, for which individuals were censored only after June 30, 2021).

Estimating the effect of a treatment only among uncensored individuals is known to induce selection bias, as those who lost Medicaid coverage, died, or were enrolled late in the study may have been systematically different from those who did not experience these events. To estimate the outcomes that would have been observed had the entire population been uncensored, we created inverse probability of censoring weights. These weights used the exposure and outcome history of uncensored individuals to estimate the outcomes that would have been observed in the whole population, had there been no loss to follow-up (Robins & Hernán, 2020).

Appendix C: Statistical analysis and models

All statistical models of difference-in-differences for main effects and interactions were generalized estimating equations (GEE) run in R version 4.1.2 using package 'geepack' (Halekoh et al., 2006). GEE models are a way of fitting generalized linear models using data with repeated observations of the same unit (in this case, each patient in the study) so that the observations are not independent of each other.

The difference-in-difference models were specified with a binomial distribution (outcomes were 0 if the outcome did not happen and 1 if the outcome did happen) and a log link function. The log link function produces effect estimates of the relative risk ratio, or the change in percent of the risk of an outcome from baseline to each follow-up period among PRS patients, divided by the same change from baseline to each follow-up period among comparison patients. Because PRS patients and comparison patients were selected to have nearly the same baseline risk of each outcome, the relative risk ratio approximates the true relative risk of the outcome for PRS patients versus the comparison patients.

The statistical significance of the main effect of PRS was assessed using a joint test of the treatment-by-time interaction term in each model with a $P < 0.05$ threshold. This corresponds with a less than five percent chance that a difference as large or larger than what was observed would be seen by random chance if there is truly no difference between the exposed and unexposed participants.

The impacts of peer recovery services were measured by estimating the parameters of a generalized linear model using a generalized estimating equation approach (Halekoh et al., 2006). All primary outcome models had the following form:

$$y_{i,g} = \alpha_g + \lambda_p + x_{g,p}\beta_p + \epsilon_{i,g,p}$$

The variables in the above model are defined as:

$y_{i,g}$: Measured outcome of interest for participant *i* in exposure group *g* during follow-up periods *p*.

α_g: Estimate of average baseline (pre-enrollment) outcome measure in each exposure group *g*.

λ_p: Estimate of period effects (independent of exposure) for follow-up periods *p*, defined as: 1-3 months, 4-6 months, 7-9 months, and 10-12 months post first peer recovery session.

$x_{g,p}$: Indicator for exposure group in follow-up periods *p*.

β_p: The difference in difference for PRS treatment group in each follow-up period (the estimand of interest)

$\epsilon_{i,g,p}$: Residual variation for participant *i* in exposure group *g* in follow-up periods *p*, expected to follow a binomial distribution.

Per-protocol analysis

We included patients admitted to inpatient treatment during the first quarter in the per-protocol population, as inpatient treatment appeared to have been largely incompatible with continuous PRS treatment (just 10 of 101 PRS initiators who were admitted to inpatient treatment completed the minimum amount of PRS), and such people will be present in any future population that initiates PRS.

Therefore, even if steps are taken to ensure all PRS initiators who can adhere to the service do so, a certain number will not be able to do so for reasons beyond the control of program administrators.

Patients who did not complete the minimum exposure were censored from the analysis. Inverse probability of censoring weights similar to those described above were estimated, such that the per-protocol population reflects both baseline and first quarter characteristics of patients who did not complete per-protocol treatment (Hernán & Robins, 2017).

Analysis of per-protocol models was completed with weighted GEE models similar to those described above. Statistical significance was measured with the $P < .05$ threshold. However, because the smaller sample of patients included in the per-protocol analysis requires a greater effect size to achieve statistical significance, we also attempted to assess the practical significance of the estimated per-protocol treatment effects.

Subgroup analysis

To ensure that we properly accounted for differences in the propensity of treatment for each subgroup, we estimated new inverse probability of treatment weights for each subgroup analysis. In these new IPTWs, we interacted the subgroup variable with the time-varying outcome variables at baseline and the binary SUD diagnosis variables in the logistic regression formula predicting the propensity of treatment, while leaving the rest of the formula the same as the IPTWs for the primary analysis.

For all subgroup analyses, we ran GEE models with the same structure as the primary models, with the addition of an interaction term between the subgroup variable of interest and the difference-in-difference interaction term. This returned a ratio of relative risk ratios, which essentially estimated the percent change in risk for PRS patients relative to comparison group patients for the subgroup coded 1 (i.e., males), divided by the same for the subgroup coded 0 (i.e., females). In other words, it estimated the difference in treatment impacts for one group as a percent of treatment impacts for another group. Like the primary analyses, we measure statistical significance using a joint test of the treatment-by-time-by-subgroup interaction term with a $P < .05$ threshold. Results are included in Appendix D.

Appendix D: Results tables

Table A2. Descriptive statistics for treatment and comparison patients in primary analysis

Subgroup	Comparison (n = 1,227) Mean (SD) or No. (%)	Treatment (n = 1,227) Mean (SD) or No. (%)	*P* value
Age Group (N[%])			**0.97**
18-25 years	161 (13.1)	156 (12.7)	
26-35 years	523 (42.6)	517 (42.1)	
36-45 years	297 (24.2)	304 (24.8)	
46-55 years	154 (12.6)	161 (13.1)	
56-64 years	81 (6.6)	75 (6.1)	
65+	11 (0.9)	14 (1.1)	
Marital Status (N[%])			**0.78**
Married	57 (4.6)	54 (4.4)	
Never Married	904 (73.7)	902 (73.5)	
Other	Suppressed	Suppressed	
Unknown	Suppressed	Suppressed	
Sex (N[%])			**0.25**
F	505 (41.2)	476 (38.8)	
M	722 (58.8)	751 (61.2)	
Race Bin (N[%])			**0.91**
Hispanic (any race)	54 (4.4)	57 (4.6)	
NH American Indian/Alaskan Native	99 (8.1)	110 (9.0)	
NH Black	144 (11.7)	150 (12.2)	
NH White	609 (49.6)	599 (48.8)	
Other Non-White	63 (5.1)	54 (4.4)	
Unknown	258 (21.0)	257 (20.9)	
N Children Bin (N[%])			**0.78**
1 child	206 (16.8)	202 (16.5)	
2 or more children	463 (37.7)	445 (36.3)	
No children	435 (35.5)	445 (36.3)	
Unknown	123 (10.0)	135 (11.0)	

Subgroup	Comparison Mean (SD) or No. (%)	Treatment Mean (SD) or No. (%)	*P* value
Sud Alcohol (N[%])			**0.24**
0	576 (46.9)	546 (44.5)	
1	651 (53.1)	681 (55.5)	
Sud Cannabis (N[%])			**0.3**
0	855 (69.7)	830 (67.6)	
1	372 (30.3)	397 (32.4)	
Sud Opioid (N[%])			**0.96**
0	903 (73.6)	901 (73.4)	
1	324 (26.4)	326 (26.6)	
Sud Cocaine Other Stimulant (N[%])			**1**
0	447 (36.4)	448 (36.5)	
1	780 (63.6)	779 (63.5)	
Sud Other (N[%])			**0.85**
0	1,171 (95.4)	1,168 (95.2)	
1	56 (4.6)	59 (4.8)	
Ctf Dimension1a	0.5 (0.6)	0.5 (0.7)	**0.35**
Ctf Dimension1b	0.7 (0.7)	0.8 (0.7)	**0.49**
Ctf Dimension1c	1.9 (0.4)	1.9 (0.4)	**0.48**
Ctf Dimension1d	2.1 (0.9)	2.1 (0.9)	**0.65**
Ctf Dimension1e	3.5 (0.6)	3.5 (0.6)	**0.78**
Ctf Dimension1f	3.5 (0.7)	3.5 (0.7)	**0.65**

Subgroup	Comparison Mean (SD) or No. (%)	Treatment Mean (SD) or No. (%)	*P* value
Inpatient Admit Varying (N[%])			**0.91**
0	1,191 (97.1)	1,189 (96.9)	
1	36 (2.9)	38 (3.1)	
Inpatient Complete Varying (N[%])			**0.89**
0	1,203 (98.0)	1,201 (97.9)	
1	24 (2.0)	26 (2.1)	
Outpatient Admit Varying (N[%])			**0.38**
0	769 (62.7)	747 (60.9)	
1	458 (37.3)	480 (39.1)	
Outpatient Complete Varying (N[%])			**0.74**
0	1,097 (89.4)	1,091 (88.9)	
1	130 (10.6)	136 (11.1)	
Inpatient Tx Yn (N[%])			**0.6**
0	405 (33.0)	392 (31.9)	
1	822 (67.0)	835 (68.1)	
Outpatient Tx Yn (N[%])			**0.95**
0	157 (12.8)	159 (13.0)	
1	1,070 (87.2)	1,068 (87.0)	
Region (N[%])			**0.33**
1	54 (4.4)	57 (4.6)	
2	57 (4.6)	52 (4.2)	
3	47 (3.8)	44 (3.6)	
4	141 (11.5)	133 (10.8)	
5	71 (5.8)	51 (4.2)	
6	113 (9.2)	94 (7.7)	
7	731 (59.6)	Suppressed	
99	13 (1.1)	Suppressed	

Subgroup	Comparison Mean (SD) or No. (%)	Treatment Mean (SD) or No. (%)	*P* value
Courts Any Charge (N[%])			**0.62**
0	329 (26.8)	341 (27.8)	
1	898 (73.2)	886 (72.2)	
Courts Any Felony Charge (N[%])			**1**
0	509 (41.5)	508 (41.4)	
1	718 (58.5)	719 (58.6)	
Courts Any Conviction (N[%])			**0.53**
0	437 (35.6)	453 (36.9)	
1	790 (64.4)	774 (63.1)	
Courts Any Felony Sentence (N[%])			**0.65**
0	719 (58.6)	707 (57.6)	
1	508 (41.4)	520 (42.4)	
Courts Any Prison Sentence (N[%])			**0.5**
0	810 (66.0)	793 (64.6)	
1	417 (34.0)	434 (35.4)	
Courts Any Confined (N[%])			**0.84**
0	735 (59.9)	729 (59.4)	
1	492 (40.1)	498 (40.6)	
Courts Any Probation (N[%])			**0.37**
0	503 (41.0)	526 (42.9)	
1	724 (59.0)	701 (57.1)	
Courts Past Year Charge (N[%])			**0.71**
0	777 (63.3)	787 (64.1)	
1	450 (36.7)	440 (35.9)	
Courts Past Year Felony Charge (N[%])			**0.68**
0	905 (73.8)	915 (74.6)	
1	322 (26.2)	312 (25.4)	
Courts Past Year Conviction (N[%])			**0.85**
0	919 (74.9)	924 (75.3)	
1	308 (25.1)	303 (24.7)	
Courts Past Year Felony Sentence (N[%])			**0.49**
0	1,041 (84.8)	1,054 (85.9)	
1	186 (15.2)	173 (14.1)	

Subgroup	Comparison Mean (SD) or No. (%)	Treatment Mean (SD) or No. (%)	*P* value
Courts Past Year Prison Sentence (N[%])			**0.75**
0	1,088 (88.7)	1,094 (89.2)	
1	139 (11.3)	133 (10.8)	
Courts Past Year Confined (N[%])			**0.78**
0	1,203 (98.0)	1,200 (97.8)	
1	24 (2.0)	27 (2.2)	
Courts Past Year Probation (N[%])			**0.64**
0	1,056 (86.1)	1,065 (86.8)	
1	Suppressed	Suppressed	
Date Of First Sud Diagnosis Qy (N[%])			**0.95**
1_2016	73 (5.9)	72 (5.9)	
1_2017	43 (3.5)	54 (4.4)	
1_2018	42 (3.4)	52 (4.2)	
1_2019	58 (4.7)	54 (4.4)	
1_2020	73 (5.9)	69 (5.6)	
2_2016	76 (6.2)	65 (5.3)	
2_2017	42 (3.4)	44 (3.6)	
2_2018	59 (4.8)	53 (4.3)	
2_2019	72 (5.9)	66 (5.4)	
2_2020	55 (4.5)	49 (4.0)	
3_2016	48 (3.9)	48 (3.9)	
3_2017	43 (3.5)	45 (3.7)	
3_2018	39 (3.2)	43 (3.5)	
3_2019	67 (5.5)	65 (5.3)	
4_2015	197 (16.1)	225 (18.3)	
4_2016	59 (4.8)	51 (4.2)	
4_2017	27 (2.2)	35 (2.9)	
4_2018	74 (6.0)	63 (5.1)	
4_2019	80 (6.5)	74 (6.0)	

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Subgroup	Comparison Mean (SD) or No. (%)	Treatment Mean (SD) or No. (%)	*P* value
Date Of First Bh Mh Diagnosis Qy (N[%])			**0.99**
1_2016	116 (9.5)	108 (8.8)	
1_2017	33 (2.7)	41 (3.3)	
1_2018	43 (3.5)	41 (3.3)	
1_2019	35 (2.9)	33 (2.7)	
1_2020	46 (3.7)	43 (3.5)	
2_2016	74 (6.0)	72 (5.9)	
2_2017	36 (2.9)	35 (2.9)	
2_2018	27 (2.2)	27 (2.2)	
2_2019	46 (3.7)	43 (3.5)	
2_2020	35 (2.9)	31 (2.5)	
3_2016	40 (3.3)	43 (3.5)	
3_2017	42 (3.4)	37 (3.0)	
3_2018	32 (2.6)	38 (3.1)	
3_2019	46 (3.7)	42 (3.4)	
4_2015	389 (31.7)	430 (35.0)	
4_2016	62 (5.1)	50 (4.1)	
4_2017	33 (2.7)	35 (2.9)	
4_2018	48 (3.9)	41 (3.3)	
4_2019	44 (3.6)	37 (3.0)	
Nonfatal Overdose Varying (N[%])			**0.72**
0	1,213 (98.9)	1,210 (98.6)	
1	14 (1.1)	17 (1.4)	
Cw Mal Report Varying (N[%])			**1**
0	Suppressed	Suppressed	
1	Suppressed	Suppressed	
Hc Visits Varying (N[%])			**0.4**
0	656 (53.5)	678 (55.3)	
1	571 (46.5)	549 (44.7)	

Subgroup	Comparison Mean (SD) or No. (%)	Treatment Mean (SD) or No. (%)	*P* value[a]
Maxis No Housing Record (N[%])			**0.72**
0	1,123 (91.5)	1,117 (91.0)	
1	104 (8.5)	110 (9.0)	
Maxis Recorded Unknown Declined Varying (N[%])			**0.6**
0	1,058 (86.2)	1,048 (85.4)	
1	169 (13.8)	179 (14.6)	
Maxis Incarc Varying (N[%])			**0.77**
0	Suppressed	Suppressed	
1	Suppressed	Suppressed	
Maxis Unstable Housing Varying (N[%])			**0.84**
0	991 (80.8)	986 (80.4)	
1	236 (19.2)	241 (19.6)	
Maxis Hospital Service Provider Varying (N[%])			**1**
0	743 (61.0)	744 (61.0)	
1	484 (39.0)	483 (39.0)	
Maxis Unstable Housing Any (N[%])			**0.44**
0	587 (47.8)	567 (46.2)	
1	640 (52.2)	660 (53.8)	

[a] P-values for count and continuous variables from 2-sided t-test. P-values for binary and categorical variables from Chi-square test.

Table A3. Descriptive statistics for treatment and comparison patients in exploratory per-protocol analysis

	No continuous treatment No. (%)	Continuous treatment No. (%)	P value
Age			**.19**
18-25	124 (12.9)	32 (12.0)	
26-35	404 (42.0)	113 (42.5)	
36-45	233 (24.2)	71 (26.7)	
46-55	121 (12.6)	40 (15.0)	
56-64	66 (6.9)	9 (3.4)	
65+	13 (1.4)	1 (0.4)	
Race/Ethnicity			**.94**
Hispanic or Latino of any race	45 (4.7)	12 (4.5)	
Non-Hispanic White	466 (48.5)	133 (50.0)	
Non-Hispanic Black	119 (12.4)	31 (11.7)	
Non-Hispanic American Indian/ Alaska Native	90 (9.4)	20 (7.5)	
Non-Hispanic Other/Multiracial	41 (4.3)	13 (4.9)	
Unknown race/ethnicity	200 (20.8)	57 (21.4)	
Sex			**<.001**
Female	348 (36.2)	128 (48.1)	
Male	613 (63.8)	138 (51.9)	
Number of children			**.017**
0	363 (37.8)	82 (30.8)	
1	166 (17.3)	36 (13.5)	
2+	328 (34.1)	117 (44.0)	
Unknown	104 (10.8)	31 (11.7)	
Number of children by sex			**<.001**
Female – 0 children	105 (10.9)	30 (11.3)	
Female – 1 children	65 (6.8)	18 (6.8)	
Female – 2+ children	135 (14.0)	68 (25.6)	
Female – Unknown children	43 (4.5)	12 (4.5)	
Male – 0 children	258 (26.8)	52 (19.5)	
Male – 1 children	101 (10.5)	18 (6.8)	
Male – 2+ children	193 (20.1)	49 (18.4)	
Male – Unknown children	61 (6.3)	19 (7.1)	
Geographic Region			**<.001**
Twin Cities metro area	642 (66.8)	144 (54.1)	
Other	319 (33.2)	122 (45.9)	

	No continuous treatment No. (%)	Continuous treatment No. (%)	P value
Marital status			**.76**
Married	44 (4.6)	10 (3.8)	
Never married	710 (73.9)	192 (72.2)	
Divorced/Separated/Widowed	205 (21.3)	63 (23.7)	
Unknown	2 (0.2)	1 (0.4)	
Diagnosed opioid use disorder			**.45**
No	711 (74)	190 (71.4)	
Yes	250 (26)	76 (28.6)	
Baseline mental health status			**.021**
Severe mental illness	233 (24.2)	82 (30.8)	
Severe and persistent mental illness	323 (33.6)	95 (35.7)	
Not SMI/SPMI	405 (42.1)	89 (33.5)	
Baseline past year courts charge			**.48**
No	611 (63.6)	176 (66.2)	
Yes	350 (36.4)	90 (33.8)	
Baseline: Nonfatal overdose			**.033**
No	922 (95.9)	263 (98.9)	
Yes	39 (4.1)	3 (1.1)	
3-month follow-up: Nonfatal overdose			**.30**
No	900 (95.7)	259 (97.4)	
Yes	40 (4.3)	7 (2.6)	
3-month follow-up: Inpatient treatment			**.003**
No	849 (90.3)	256 (96.2)	
Yes	91 (9.7)	10 (3.8)	
Baseline: Completed outpatient treatment			**.41**
No	779 (81.1)	209 (78.6)	
Yes	182 (18.9)	57 (21.4)	
3-month follow-up: Completed outpatient treatment			**.19**
No	862 (91.7)	251 (94.4)	
Yes	78 (8.3)	15 (5.6)	

	No continuous treatment No. (%)[a]	Continuous treatment No. (%)[a]	P value[b]
Baseline healthcare visits			**.98**
No	303 (31.5)	83 (31.2)	
Yes	658 (68.5)	183 (68.8)	
3-month follow-up: Healthcare visits			**.0016**
No	278 (29.6)	52 (19.5)	
Yes	662 (70.4)	214 (80.5)	
Baseline housing instability			**.46**
No	777 (80.9)	209 (78.6)	
Yes	184 (19.1)	57 (21.4)	
3-month follow-up: Housing instability			**.56**
No	786 (83.6)	227 (85.3)	
Yes	154 (16.4)	39 (14.7)	
Baseline screened-in child maltreatment report			**<.001**
No	950 (98.9)	254 (95.5)	
Yes	11 (1.1)	12 (4.5)	
3-month follow-up: Screened-in child maltreatment report			**.50**
No	930 (98.9)	265 (99.6)	
Yes	10 (1.1)	1 (0.4)	

[a] Continuous treatment defined as three consecutive months with at least one peer recovery claim per month in the first quarter of treatment, or a minimum of six peer recovery claims in the first quarter of treatment.b P-value of Pearson's Chi-squared test.

[b] P-value of Pearson's Chi-squared test.

Figure A2: Map of percent of eligible patients using PRS by region in Minnesota

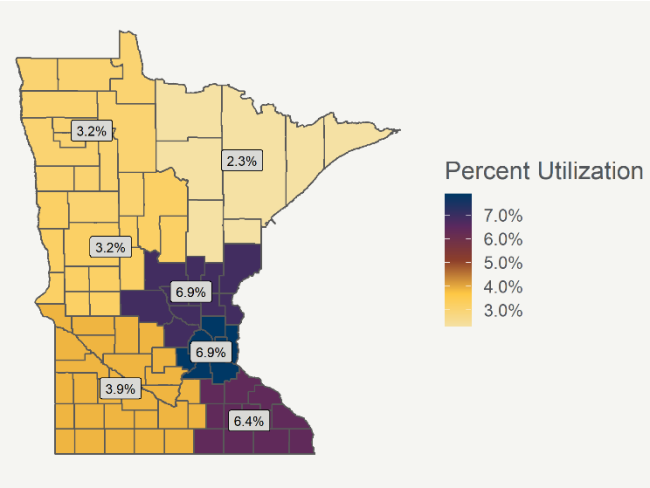


Table A4: Estimated marginal means and relative risk ratios for GEE differences-in-differences models of the impact of having at least one PRS session on SUD treatment and recovery outcomes

	Estimated means (95% confidence intervals)					Difference-in-differences analysis (95% confidence intervals)				
Outcome	**Baseline**	**3 months**	**6 months**	**9 months**	**12 months**	**Baseline to 3 months**	**Baseline to 6 months**	**Baseline to 9 months**	**Baseline to 12 months**	***P* value**
1+ Non-Fatal Overdose										
Participant	3.8 (2.3 to 6.4)	3.8 (2.6 to 5.5)	2.8 (1.8 to 4.3)	3.3 (2.1 to 5.0)	3.1 (2.0 to 4.6)	1.02 (0.47 to 2.21)	0.67 (0.31 to 1.49)	1.35 (0.55 to 3.34)	1.40 (0.61 to 3.19)	0.24
Non-participant	3.3 (2.3 to 4.9)	3.2 (2.2 to 4.8)	3.6 (2.4 to 5.4)	2.1 (1.2 to 3.6)	1.9 (1.2 to 3.1)					
All-Cause Mortality										
Participant		0.4 (0.2 to 1.0)	0.7 (0.4 to 1.4)	1.4 (0.9 to 2.4)	1.8 (1.1 to 3.0)	1.7 (0.4 to 7.2)	1.6 (0.5 to 4.9)	3.3 (1.1 to 10.1)	2.8 (1.0 to 7.8)	0.63
Non-participant		0.2 (0.1 to 0.8)	0.5 (0.2 to 1.1)	0.4 (0.2 to 1.2)	0.6 (0.3 to 1.5)					
Inpatient Treatment Admission										
Participant	21.1 (18.1 to 24.6)	8.1 (6.3 to 10.2)	13.7 (11.5 to 16.4)	16.8 (14.3 to 19.7)	20.6 (17.9 to 23.7)	1.14 (0.77 to 1.69)	1.15 (0.83 to 1.59)	1.00 (0.75 to 1.34)	1.04 (0.8 to 1.37)	0.38
Non-participant	19.9 (17.5 to 22.6)	6.7 (5.1 to 8.6)	11.3 (9.2 to 13.8)	15.8 (13.4 to 18.6)	18.6 (16.0 to 21.5)					
Outpatient Treatment Completion										
Participant	19.3 (16.8 to 22.2)	7.4 (5.9 to 9.3)	9.1 (7.4 to 11.2)	10.7 (8.9 to 13.0)	12.1 (10.1 to 14.5)	2.37*** (1.48 to 3.8)	1.79** (1.2 to 2.67)	1.64** (1.14 to 2.36)	1.61** (1.14 to 2.27)	0.010**
Non-participant	19.1 (16.8 to 21.8)	3.1 (2.1 to 4.5)	5.0 (3.8 to 6.7)	6.5 (5.0 to 8.4)	7.5 (5.9 to 9.5)					
Housing Instability										
Participant	19.5 (16.8 to 22.5)	18.3 (15.6 to 21.4)	16.7 (14.1 to 19.7)	17.3 (14.7 to 20.4)	16.2 (13.7 to 19.3)	1.11 (0.91 to 1.36)	0.94 (0.74 to 1.19)	0.97 (0.76 to 1.24)	0.91 (0.7 to 1.18)	0.34
Non-participant	19.2 (16.7 to 22.1)	16.2 (13.6 to 19.3)	17.5 (14.9 to 20.7)	17.6 (14.9 to 20.7)	17.7 (15.0 to 20.8)					
1+ Physician Office Visit										
Participant	69.3 (66.1 to 72.6)	72.9 (69.8 to 76.2)	59.1 (55.7 to 62.8)	54.6 (51.1 to 58.3)	52.0 (48.5 to 55.8)	1.16*** (1.07 to 1.26)	1.08 (0.98 to 1.18)	1.00 (0.91 to 1.1)	0.98 (0.88 to 1.09)	0.001**
Non-participant	68.5 (65.3 to 71.9)	62.3 (59.0 to 65.8)	54.4 (51.0 to 58.0)	54.0 (50.7 to 57.6)	52.5 (49.2 to 56.1)					
1+ Screened-In Child Welfare Maltreatment Report										
Participant	3.5 (2.1 to 5.7)	1.2 (0.6 to 2.8)	2.5 (1.4 to 4.2)	2.1 (1.1 to 4.1)	1.9 (0.9 to 4.0)	0.55 (0.17 to 1.75)	0.97 (0.34 to 2.74)	0.80 (0.27 to 2.34)	1.47 (0.42 to 5.22)	0.75
Non-participant	3.3 (2.1 to 5.2)	2.1 (1.1 to 3.9)	2.4 (1.3 to 4.4)	2.5 (1.4 to 4.3)	1.2 (0.5 to 2.7)					

**p < .05 **p < .01 ***p < .001*

Table A5: Estimated marginal means and relative risk ratios for GEE differences-in-differences models of the impact of having sustained PRS participation (6+ sessions/3+ consecutive months with a session) on SUD treatment and recovery outcomes

	Estimated means (95% confidence intervals)					Difference-in-differences analysis (95% confidence intervals)				
	Baseline	3 months	6 months	9 months	12 months	Baseline to 3 months	Baseline to 6 months	Baseline to 9 months	Baseline to 12 months	*P* value
Housing										
Participant	16.5 (11.5 to 23.5)	13.4 (8.9 to 20.1)	15.3 (10.2 to 22.9)	14.6 (9.6 to 22.2)	13 (8.3 to 20.4)	1.04 (0.68 to 1.58)	1.34 (0.82 to 2.19)	1.33 (0.81 to 2.19)	1.25 (0.71 to 2.18)	0.663
Non-participant	19 (16.3 to 22.1)	14.9 (12.5 to 17.7)	13.1 (10.9 to 15.8)	12.7 (10.5 to 15.3)	12 (9.9 to 14.5)					
Child welfare										
Participant	4.7 (2 to 10.8)	0.2 (0 to 1.7)	1.2 (0.3 to 4.9)	3 (1.1 to 8.2)	1 (0.2 to 4.7)	0.06* (0.01 to 0.63)	0.30 (0.06 to 1.55)	0.95 (0.2 to 4.55)	0.22 (0.03 to 1.46)	0.065
Non-participant	3.2 (1.9 to 5.3)	2.5 (1.3 to 4.7)	2.8 (1.6 to 4.9)	2.1 (1.1 to 4)	3 (1.7 to 5.1)					
Healthcare										
Participant	67.8 (60.3 to 76.4)	76.1 (69 to 83.8)	63.9 (56.2 to 72.6)	60.4 (52.5 to 69.4)	58.8 (50.9 to 67.9)	1.24* (1.07 to 1.44)	1.14 (0.96 to 1.34)	1.09 (0.92 to 1.3)	1.19 (0.98 to 1.44)	0.042*
Non-participant	67.8 (64.5 to 71.3)	61.2 (57.8 to 64.8)	56.2 (52.8 to 59.8)	55.2 (51.8 to 58.9)	49.5 (46.1 to 53.2)					
Inpatient treatment										
Participant	19.8 (14.4 to 27.4)	9 (6.7 to 12.2)	16.1 (11.7 to 22)	18.9 (13.9 to 25.7)	20.8 (15.5 to 27.7)	1.14 (0.69 to 1.91)	1.21 (0.74 to 1.99)	1.12 (0.68 to 1.83)	1.05 (0.66 to 1.69)	0.733
Non-participant	19.1 (16.6 to 21.9)	7.6 (5.8 to 9.9)	12.8 (10.6 to 15.5)	16.2 (13.8 to 19.1)	19 (16.4 to 22)					
Outpatient treatment										
Participant	21 (15.2 to 28.9)	6.5 (3.5 to 12.1)	9.6 (5.9 to 15.5)	12.1 (7.9 to 18.6)	14 (9.3 to 21)	1.62 (0.79 to 3.33)	1.50 (0.83 to 2.73)	1.46 (0.84 to 2.56)	1.41 (0.85 to 2.33)	0.719
Non-participant	19.6 (17.2 to 22.5)	3.8 (2.8 to 5.1)	6 (4.7 to 7.7)	7.8 (6.3 to 9.7)	9.3 (7.6 to 11.4)					
Nonfatal overdose										
Participant	5.6 (2.9 to 10.7)	4.4 (2.3 to 8.2)	0.5 (0.1 to 2.7)	4.8 (2.2 to 10.8)	4 (1.5 to 10.8)	0.75 (0.3 to 1.9)	0.09* (0.01 to 0.54)	1.17 (0.35 to 3.89)	0.87 (0.23 to 3.3)	0.086
Non-participant	4.2 (2.8 to 6.3)	4.4 (3.1 to 6.3)	4.5 (3.1 to 6.5)	3.1 (2.1 to 4.6)	3.4 (2.3 to 5.2)					
Mortality										
Participant			0.3 (0 to 2)	1.2 (0.4 to 4.1)	1.5 (0.4 to 5.2)			1.73 (0.24 to 12.69)	1.6 (0.4 to 6.6)	0.536
Non-participant			0.2 (0.1 to 0.9)	0.6 (0.2 to 1.4)	1 (0.5 to 2)					

**p < .05 **p < .01 ***p < .001*

Appendix E: Per-protocol exploratory outcome results

Figure A3. Exploratory outcome results of per-protocol analysis of Peer Recovery Services utilization in a propensity score-matched cohort

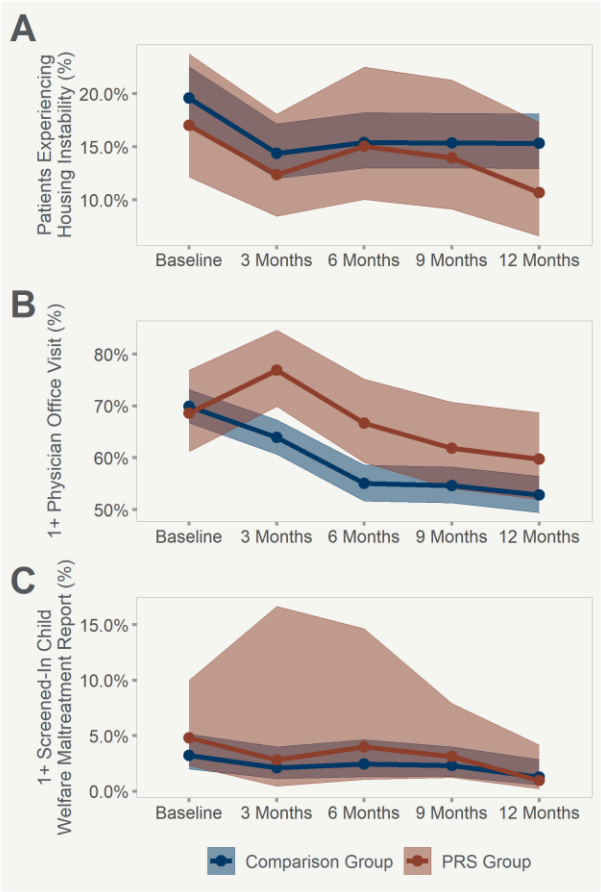


Figure 4 shows results of the per-protocol analysis of exploratory outcomes. Panel A shows no significant differences in probability of housing instability for PRS patients relative to comparison patients (overall *P* = .68). PRS patients and comparison patients both experienced reductions in housing instability over follow-up. Although PRS patients were marginally less likely than comparison patients to be classified as having unstable housing in the fourth quarter of follow-up, confidence intervals around these estimates are very wide.

Panel B shows that PRS patients were more likely to have a physician office visit in each of the follow-up quarters (overall *P* = .023). This effect was statistically significant in the first three follow-up quarters. In the first quarter of follow-up, PRS patients were 23 percent (95% CI: 8%, 40%) more likely than comparison patients to have an office visit. The difference only attenuated slightly by quarter four, when PRS patients were 15 percent more likely to have an office visit (95% CI: -4%, 38%).

There was not an overall significant difference in risk of screened-in child maltreatment report for PRS versus comparison patients throughout follow-up (overall *P* = .94), nor were there significant differences in any individual quarter of follow-up.

Appendix F: Subgroup analysis results

We ran the same models presented in the primary analysis with interaction terms between the treatment/time treatment impact and four individual subgroups: racial category (non-Hispanic white/non-white), sex (male/female), opioid use disorder (patients diagnosed with OUD/patients not diagnosed with OUD), and geography (Twin Cities Metro area counties/non-metro). Tables showing the relative risk ratios for differential treatment impacts and overall joint significance tests and plots showing estimated marginal population means for the PRS participants and matched comparison group for each quarter of follow-up are available in the appendices for each subgroup. As explained in the methods, mortality is not included in subgroup analyses, as there were too few events for all subgroups to accurately test our hypotheses.

We also recognize white versus non-white is a less than ideal grouping. Racial and ethnic groups differ tremendously in current and historical material conditions that influence how PRS participation will affect their wellbeing. That said, there were too few PRS participants in each racial or category collected in the administrative data to conduct the statistical analysis; in technical parlance, the models do not have the sample size necessary to converge. Therefore, we had two choices: group together the racial categories to white and non-white or exclude the subgroup analysis. We erred towards transparency in including the results, as we think they may provide some insight into the experiences of different Minnesotans.

To understand group-specific trajectories better, we did look at the relative risk for each outcome at the baseline and each follow-up quarter by computing means, adjusted with the inverse probability weights described above. While this type of descriptive analysis does not give the ability to test hypotheses or assess whether differences are statistically significant, it does provide more detailed estimates of whether there were any differences in outcomes across treatment and comparison patients of distinct racial groups for each outcome. To protect against any chance of being able to identify an individual and their outcomes, we followed best practices in suppressing results for any quarter with less than 10 event outcomes in the treatment or control group. The result is data for the vast majority of quarters for most distinct racial groups aside from non-Hispanic white patients was suppressed. As such we do not include those results here.

Race

Figure A4: Main outcomes among PRS participants and comparison patients by racial group in a propensity-score-matched cohort

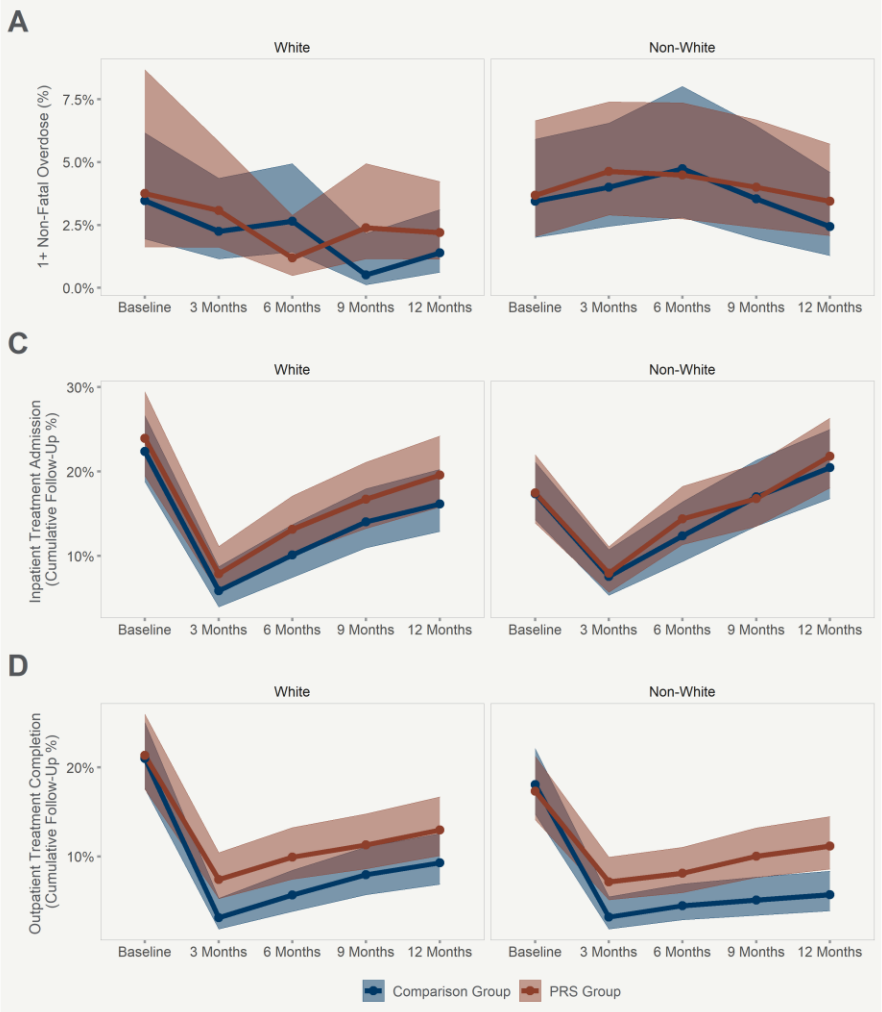
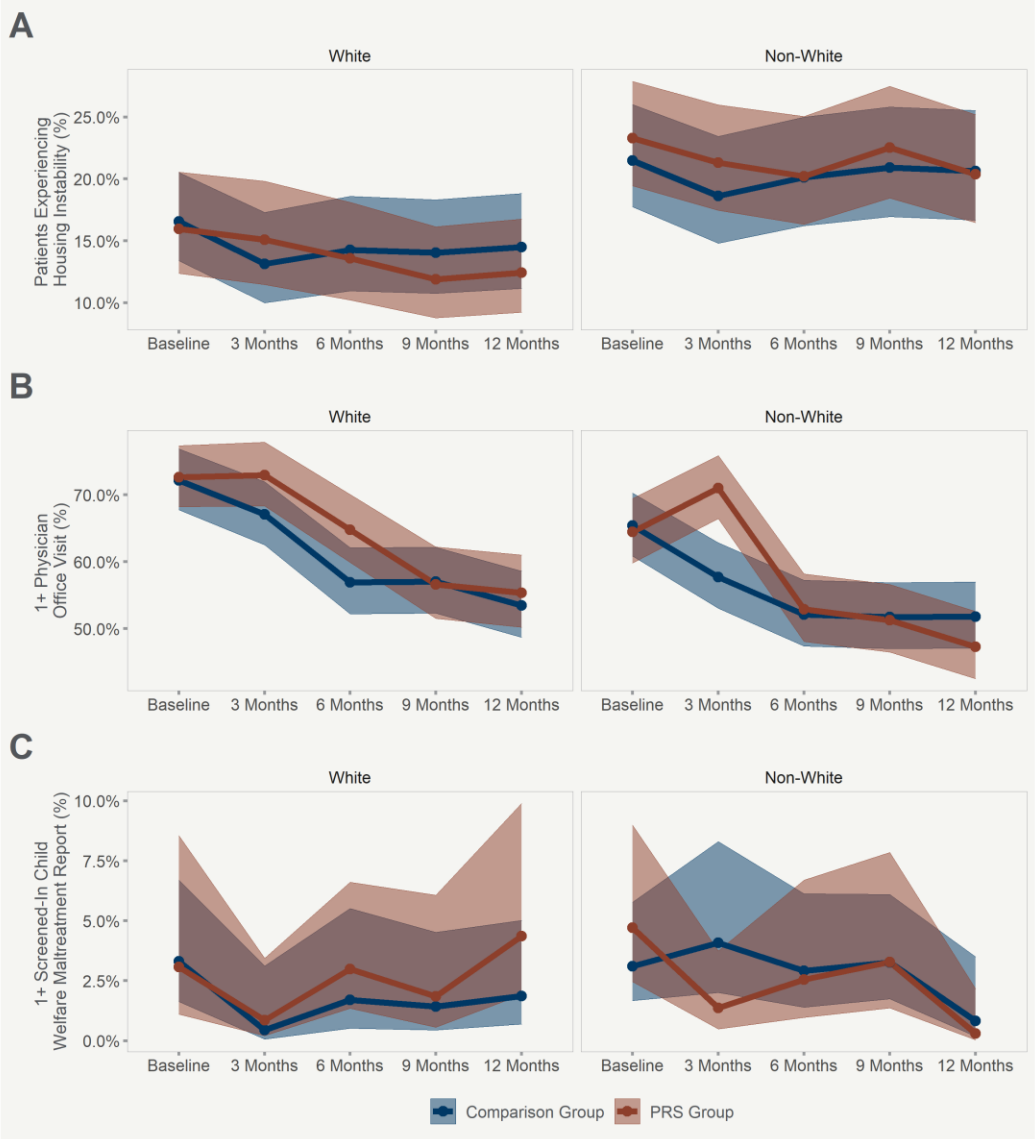


Figure 5 shows primary SUD and treatment outcomes for PRS initiators compared to the matched comparison group by racial group. Across all four outcomes, joint tests of significance for heterogenous treatment impacts showed no significant differences in the effect of PRS on outcomes between white and non-white patients. Panel A shows that trajectories of diagnosed non-fatal overdoses differed over time for non-Hispanic white patients versus non-white patients (overall P = 0.28), but the patterns varied and did not suggest that one group had consistently favorable results. Panels B, and C show very similar patterns for non-Hispanic white and non-white patients in the PRS and comparison groups for inpatient treatment admission and outpatient treatment completion.

Figure A3: Exploratory outcomes among PRS participants and comparison patients by racial group in a propensity-score-matched cohort



Note: White defined as white race and non-Hispanic ethnicity. Non-white defined as any race other than white, including multiracial, or Hispanic ethnicity.

Figure 6 shows exploratory outcomes by racial group for PRS initiators compared to non-PRS initiators. There were no significant differences in overall treatment effects for white versus non-white patients for housing instability, physician office visits, or child welfare maltreatment reports. Panel B shows that the significant increase in physician office visits in the first quarter was limited to non-white PRS patients and non-significant for white PRS patients, and the overall difference in treatment effects neared, but did not reach, statistical significance (P = 0.07).

Sex

Figure A4: Main outcomes among PRS participants and comparison patients by sex in a propensity-score-matched cohort

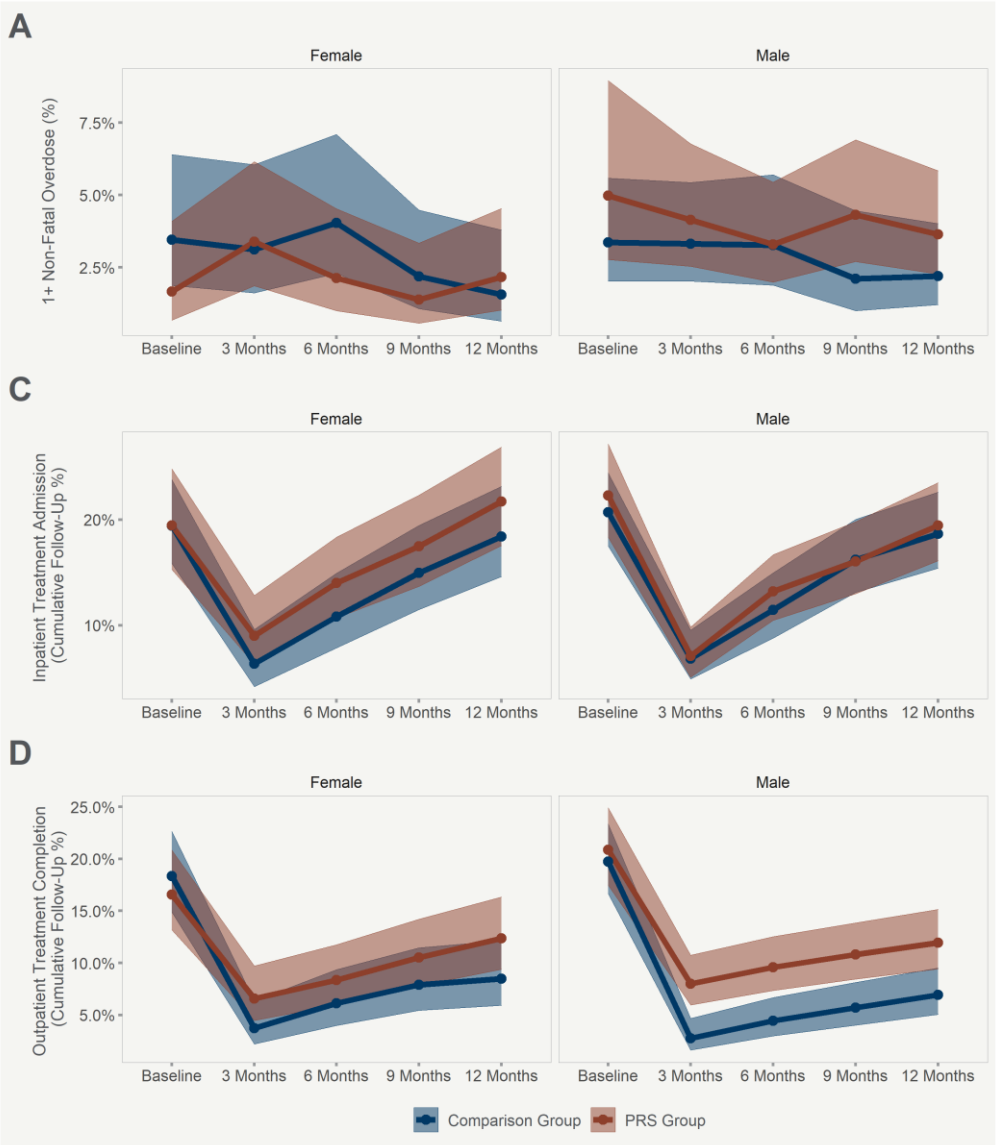


Figure 7 shows results for models of primary SUD and treatment outcomes by sex. Joint tests of significance for differences in treatment effects by sex were insignificant for all four outcomes. Levels and trends for PRS and comparison patients were similar for both male and female patients in diagnosed non-fatal overdoses, inpatient treatment admission, and outpatient treatment completion.

Figure A5: Exploratory outcomes among PRS participants and comparison patients by sex in a propensity-score-matched cohort

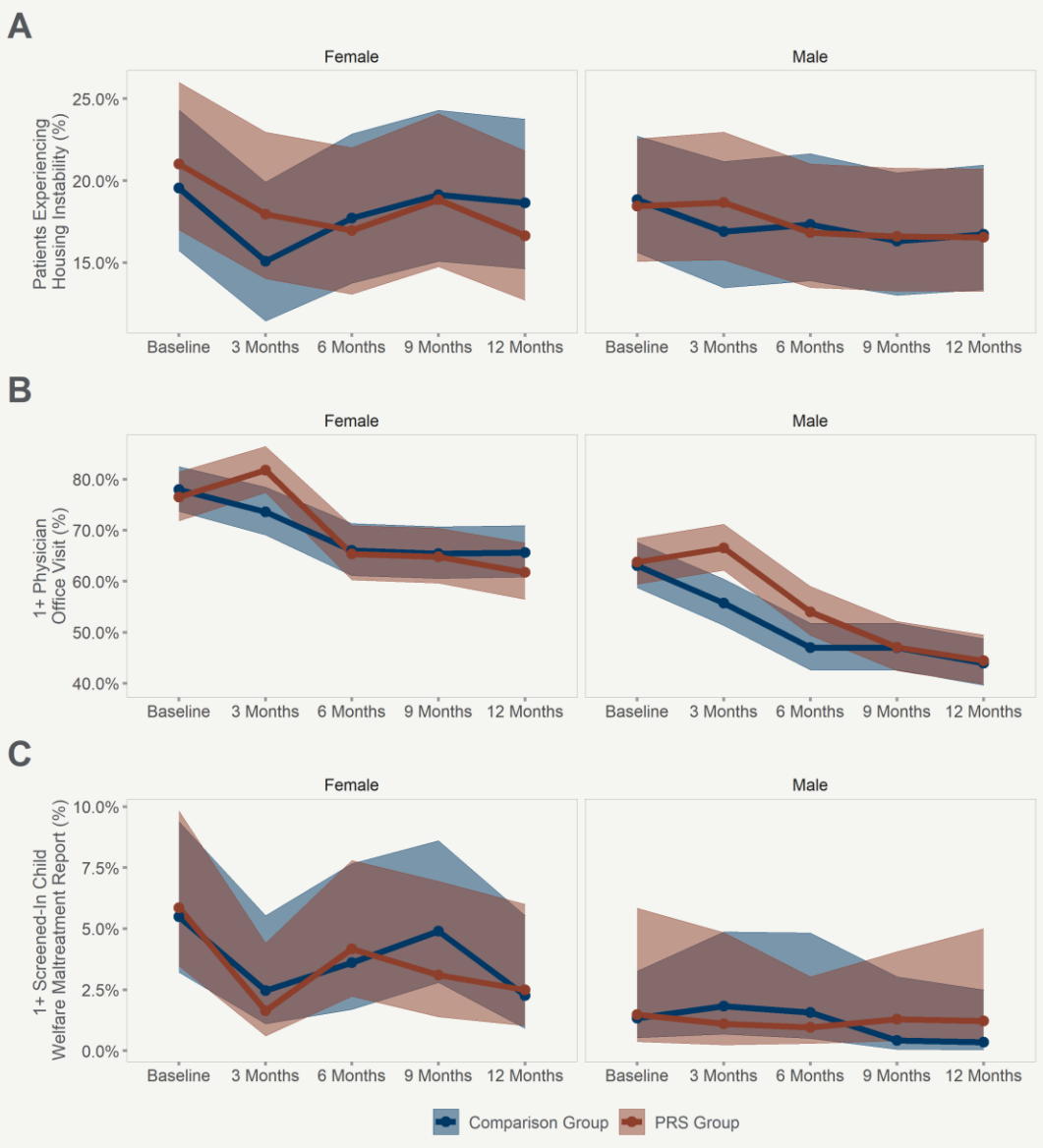


Figure 8 shows models of the three exploratory outcomes by sex. For all three outcomes, there were no significant differences in treatment effects of PRS between men and women. Levels and trends varied slightly across outcomes by sex, but all joint tests of significance for heterogenous treatment impacts were insignificant.

Opioid Use Disorder

Figure A6: Main outcomes among PRS participants and comparison patients by opioid use disorder status in a propensity-score-matched cohort

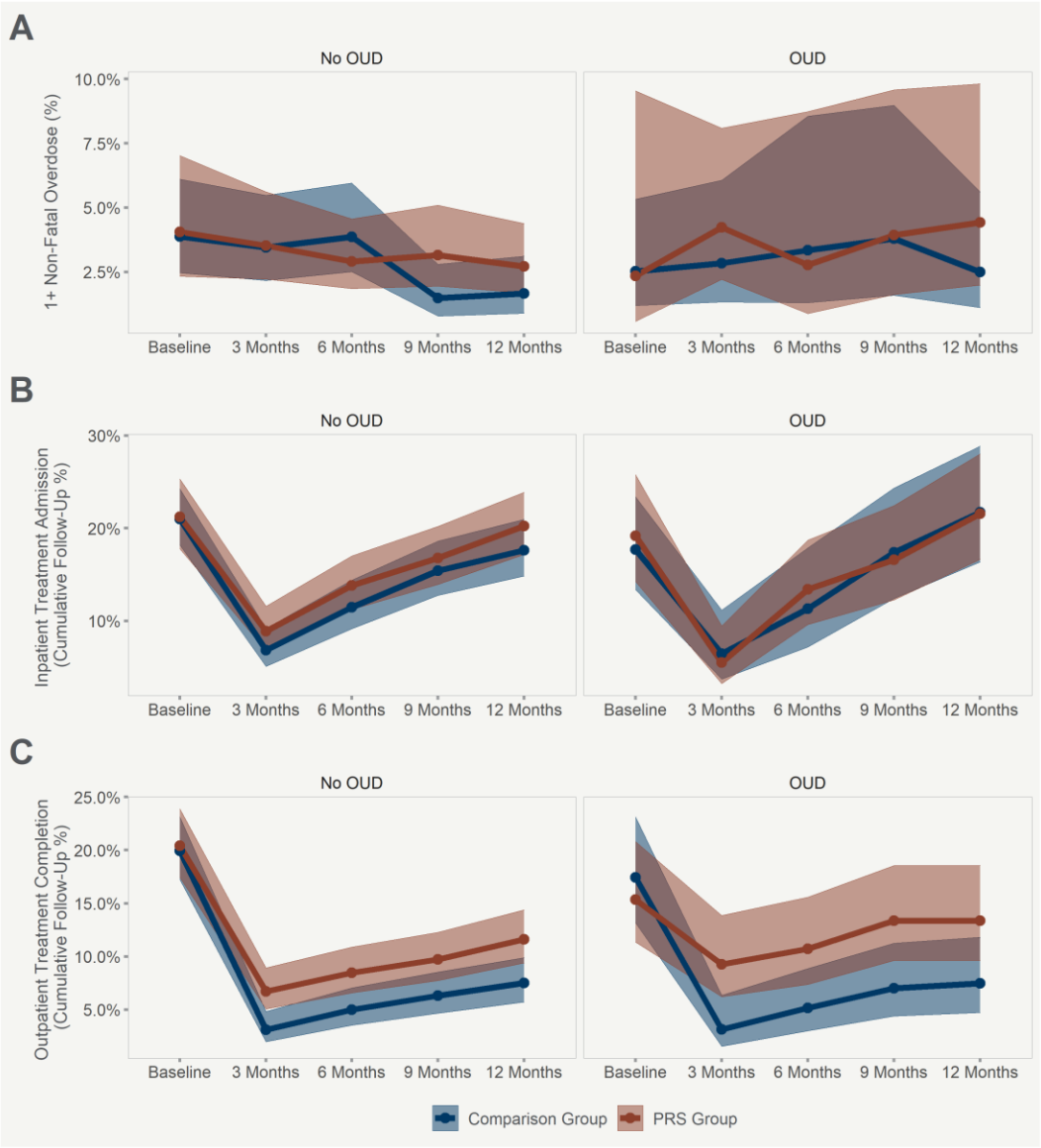


Figure 9 shows SUD treatment and severity outcomes by opioid use disorder status. All joint tests of significance for heterogenous treatment effects for diagnosed non-fatal overdose, inpatient treatment admission, and outpatient treatment completion were insignificant. Levels and patterns for PRS patients and comparison patients differed slightly across opioid use disorder status for outcomes, but no differences were indicative of statistically higher or lower probability among PRS patients.

Figure A7: Exploratory outcomes among PRS participants and comparison patients by opioid use disorder status in a propensity-score-matched cohort

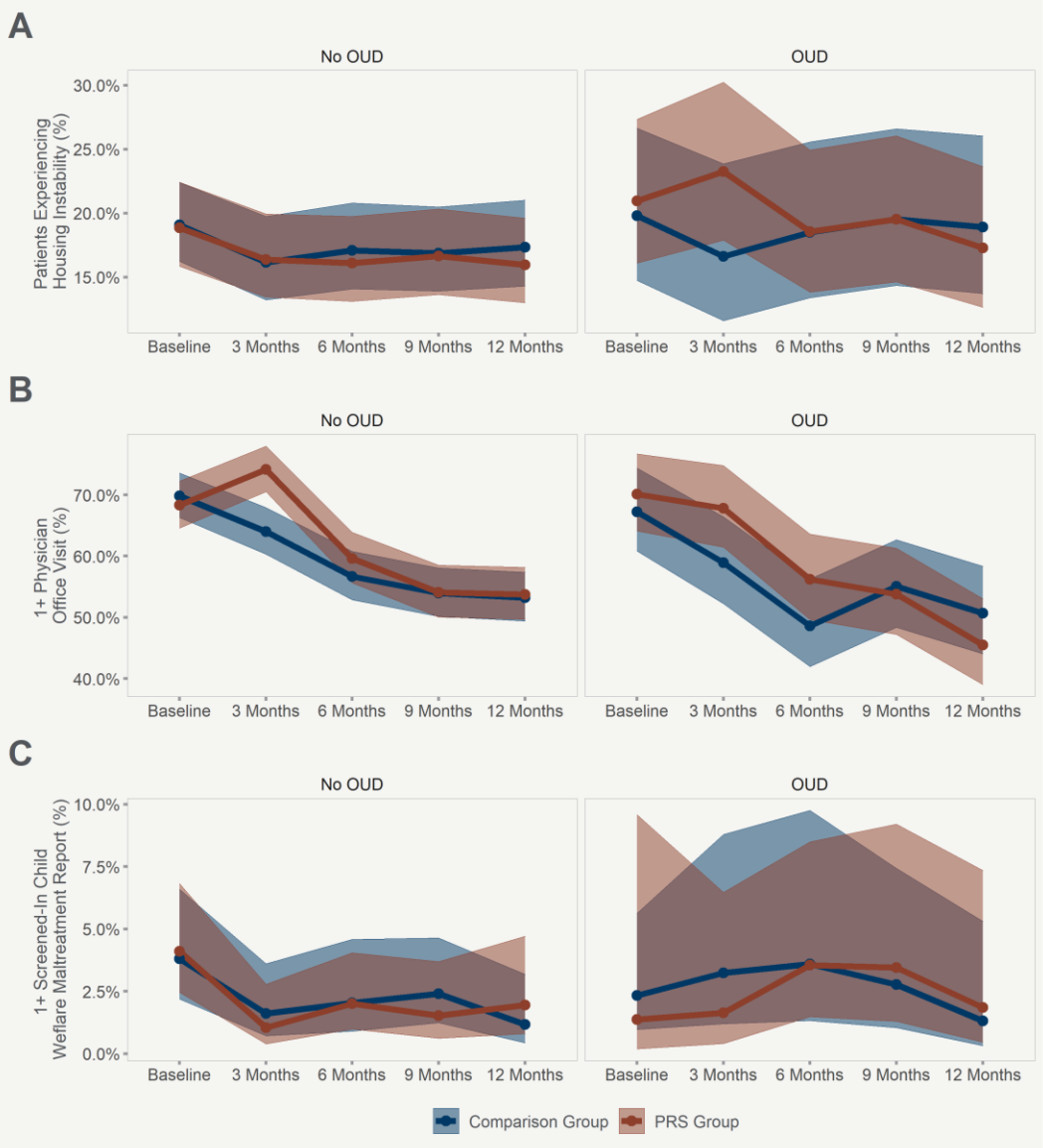
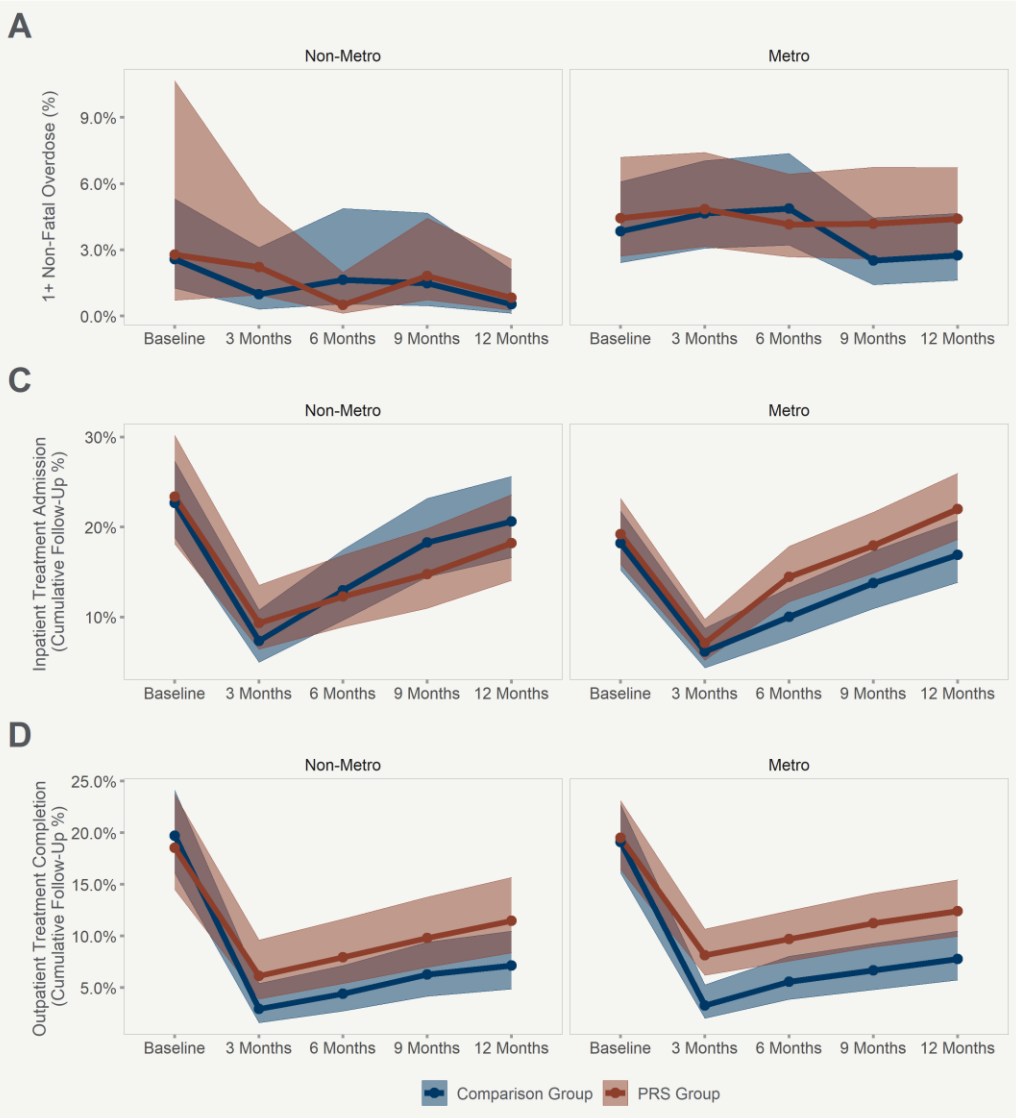


Figure 10 shows exploratory outcome results by opioid use disorder status. Similar to the main outcomes, joint tests of significance showed no significant differences in treatment effects for PRS initiators with diagnosed opioid use disorder compared to PRS patients without. Panels A and C show marginally different trajectories throughout the follow-up period for patients with opioid use disorder for housing instability and child welfare reports respectively, but these differences were not statistically significant. Panel B shows that the significant increase in physician's office visit in the first three months is contained only to PRS patients without a diagnosed OUD, though the overall difference in treatment effects was not statistically significant (overall P = 0.49).

Metro

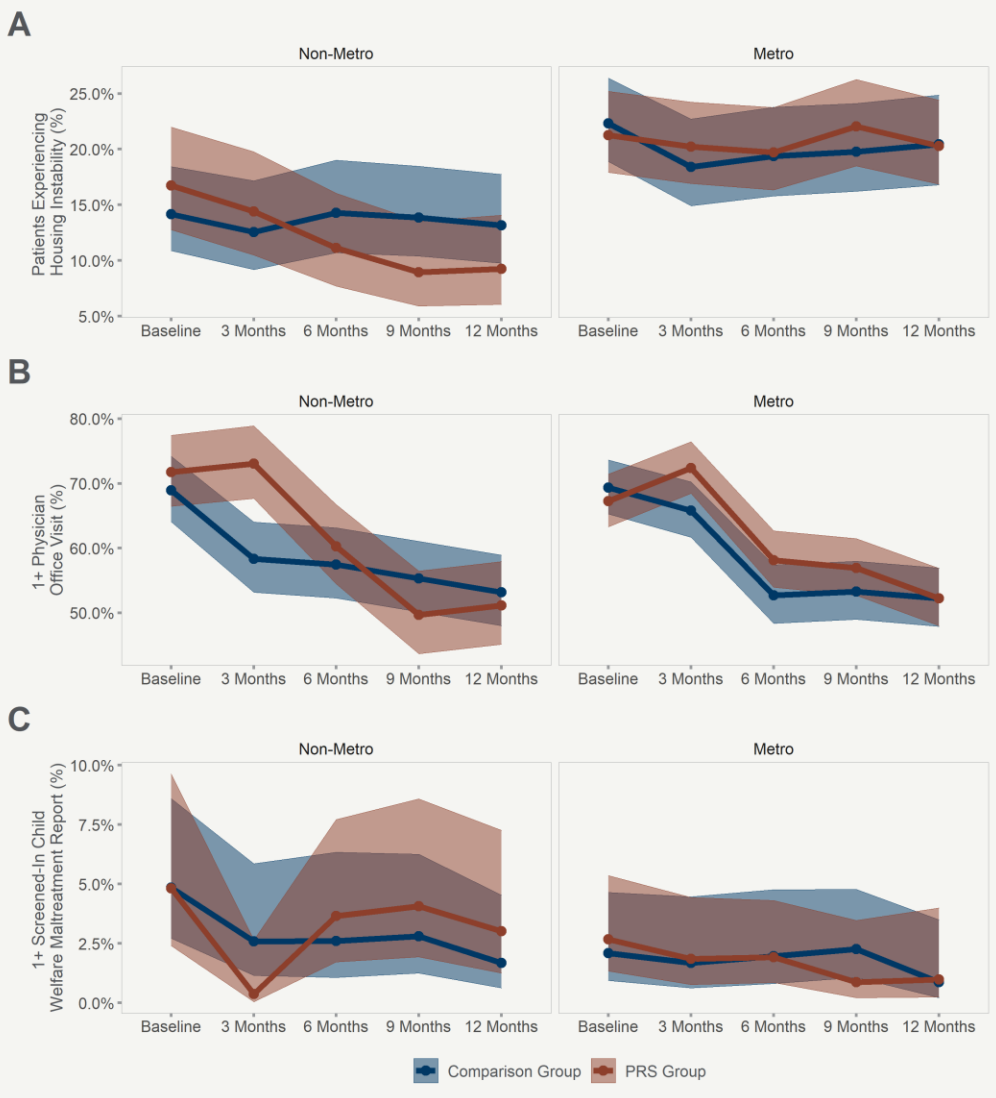
Figure A8: Main outcomes among PRS participants and comparison patients by geography in a propensity-score-matched cohort



Note: Metro is defined as residing in any county in the 7-county Twin Cities metro area. Non-metro is defined as residing in any county outside of 7-county TC metro area.

Figure 11 contains plots with results for main outcomes by metro versus non-metro patients. Joint tests for heterogeneous treatment effects were insignificant in all panels for diagnosed non-fatal overdose, inpatient treatment admission, and outpatient treatment completion, meaning metro PRS patients did not have significantly different outcomes than non-metro PRS patients, relative to comparison patients. Panel B shows that PRS patients in the metro had a lower likelihood of being admitted to inpatient treatment, while those in the non-metro had a slightly higher likelihood, but differences for both groups were statistically insignificant. Panel C shows that the increases in outpatient treatment completion for metro PRS patients were statistically significant, while those for non-metro PRS patients were not, but the relative risks were very similar across groups.

Figure A9: Exploratory outcomes among PRS participants and comparison patients by geography in a propensity-score-matched cohort



Note: Metro is defined as residing in any county in the 7-county Twin Cities metro area. Non-metro is defined as residing in any county outside of 7-county TC metro area.

Figure 12 shows exploratory outcomes for metro versus non-metro patients. Panels A, B, and C show that joint tests were all insignificant, and the treatment effects of PRS were the same for metro and non-metro groups on housing instability, physician office visits, and child welfare reports. Levels and trends varied slightly throughout follow-up, but no differences amounted to significantly higher or lower probability of outcomes for metro PRS patients compared to non-metro PRS patients.

Tables

The tables below show estimated marginal means and relative risk ratios for the subgroup analyses.

Table A6: Estimated marginal means and relative risk ratios for GEE difference-in-differences models of the impact of having at least one PRS session on SUD treatment and recovery outcomes by racial group

	Estimated difference-in-differences (95% confidence intervals)				*P* value for interaction
	Baseline to 3 months	Baseline to 6 months	Baseline to 9 months	Baseline to 12 months	
1+ Non-Fatal Overdose					
White	1.27 (0.38 to 4.22)	0.42 (0.10 to 1.71)	4.27 (0.69 to 26.62)	1.46 (0.37 to 5.84)	0.28
Non-white	1.08 (0.41 to 2.81)	0.89 (0.36 to 2.22)	1.06 (0.35 to 3.18)	1.33 (0.48 to 3.65)	
Inpatient Treatment Admission					
White	1.26 (0.70 to 2.26)	1.22 (0.76 to 1.96)	1.12 (0.73 to 1.69)	1.13 (0.76 to 1.68)	0.91
Non-white	1.04 (0.61 to 1.78)	1.16 (0.74 to 1.83)	0.98 (0.65 to 1.48)	1.06 (0.72 to 1.56)	
Outpatient Treatment Completion					
White	2.33* (1.18 to 4.58)	1.71 (0.98 to 3.01)	1.40 (0.84 to 2.32)	1.37 (0.85 to 2.21)	0.34
Non-white	2.32* (1.20 to 4.48)	1.89* (1.07 to 3.34)	2.05* (1.20 to 3.50)	2.03* (1.21 to 3.40)	
Housing Instability					
White	1.19 (0.86 to 1.66)	0.99 (0.67 to 1.46)	0.88 (0.58 to 1.34)	0.89 (0.57 to 1.39)	0.80
Non-white	1.06 (0.82 to 1.37)	0.93 (0.68 to 1.27)	0.99 (0.73 to 1.35)	0.91 (0.66 to 1.26)	
1+ Physician Office Visit					
White	1.08 (0.97 to 1.21)	1.13 (1.00 to 1.28)	0.99 (0.86 to 1.13)	1.03 (0.89 to 1.19)	0.070
Non-white	1.25* (1.11 to 1.41)	1.03 (0.89 to 1.19)	1.01 (0.87 to 1.17)	0.93 (0.79 to 1.09)	
1+ Screened-In Child Welfare Maltreatment Report					
White	1.35 (0.19 to 9.48)	2.25 (0.40 to 12.82)	2.10 (0.29 to 15.34)	3.14 (0.65 to 15.05)	0.63
Non-white	0.27 (0.07 to 1.02)	0.71 (0.23 to 2.23)	0.83 (0.28 to 2.44)	0.72 (0.08 to 6.68)	

**p < .05 **p < .01 ***p < .001*

White race/ethnicity is defined as white race and non-Hispanic ethnicity.

Non-white race/ethnicity is defined as any race other than white, including multiracial, or Hispanic ethnicity.

Table A7: Estimated marginal means and relative risk ratios for GEE difference-in-differences models of the impact of having at least one PRS session on SUD treatment and recovery outcomes by sex

	Estimated difference-in-differences (95% confidence intervals)				*P* value for interaction
	Baseline to 3 months	Baseline to 6 months	Baseline to 9 months	Baseline to 12 months	
1+ Non-Fatal Overdose					
Female	2.25 (0.56 to 9.08)	1.10 (0.26 to 4.54)	1.31 (0.27 to 6.44)	2.88 (0.61 to 13.63)	0.66
Male	0.84 (0.34 to 2.09)	0.68 (0.25 to 1.82)	1.38 (0.44 to 4.31)	1.12 (0.42 to 2.95)	
Inpatient Treatment Admission					
Female	1.41 (0.77 to 2.60)	1.29 (0.78 to 2.13)	1.17 (0.75 to 1.82)	1.18 (0.78 to 1.78)	0.83
Male	0.96 (0.57 to 1.61)	1.07 (0.70 to 1.63)	0.92 (0.63 to 1.34)	0.97 (0.68 to 1.38)	
Outpatient Treatment Completion					
Female	1.95 (0.95 to 3.98)	1.52 (0.82 to 2.82)	1.48 (0.84 to 2.59)	1.62 (0.94 to 2.78)	0.61
Male	2.76* (1.46 to 5.22)	2.04* (1.21 to 3.45)	1.79* (1.11 to 2.89)	1.63* (1.04 to 2.55)	
Housing Instability					
Female	1.11 (0.81 to 1.51)	0.89 (0.62 to 1.28)	0.92 (0.63 to 1.33)	0.83 (0.55 to 1.25)	0.96
Male	1.13 (0.87 to 1.46)	0.99 (0.72 to 1.36)	1.04 (0.75 to 1.44)	1.01 (0.72 to 1.42)	
1+ Physician Office Visit					
Female	1.13* (1.02 to 1.26)	1.01 (0.89 to 1.14)	1.01 (0.89 to 1.14)	0.96 (0.84 to 1.10)	0.66
Male	1.18* (1.05 to 1.33)	1.14 (0.99 to 1.31)	0.99 (0.85 to 1.15)	1.00 (0.85 to 1.18)	
1+ Screened-In Child Welfare Maltreatment Report					
Female	0.62 (0.15 to 2.54)	1.09 (0.33 to 3.54)	0.59 (0.18 to 1.97)	1.04 (0.25 to 4.25)	0.55
Male	0.54 (0.09 to 3.19)	0.56 (0.06 to 5.66)	2.69 (0.16 to 44.77)	3.12 (0.17 to 58.39)	
**p < .05 **p < .01 ***p < .001*					

Table A8: Estimated marginal means and relative risk ratios for GEE difference-in-differences models of the impact of having at least one PRS session on SUD treatment and recovery outcomes by opioid use disorder status

	Estimated difference-in-differences (95% confidence intervals)				*P* value for interaction
	Baseline to 3 months	Baseline to 6 months	Baseline to 9 months	Baseline to 12 months	
1+ Non-Fatal Overdose					
Non-OUD	0.98 (0.41 to 2.32)	0.72 (0.30 to 1.71)	2.04 (0.71 to 5.80)	1.57 (0.58 to 4.26)	0.73
OUD	1.60 (0.25 to 10.27)	0.89 (0.19 to 4.15)	1.11 (0.23 to 5.30)	1.90 (0.45 to 7.93)	
Inpatient Treatment Admission					
Non-OUD	1.29 (0.82 to 2.01)	1.19 (0.82 to 1.73)	1.08 (0.77 to 1.51)	1.14 (0.83 to 1.56)	0.67
OUD	0.79 (0.34 to 1.84)	1.09 (0.55 to 2.15)	0.88 (0.50 to 1.56)	0.92 (0.55 to 1.54)	
Outpatient Treatment Completion					
Non-OUD	2.12** (1.21 to 3.71)	1.66* (1.03 to 2.67)	1.51 (0.98 to 2.32)	1.51* (1.01 to 2.26)	0.89
OUD	3.35* (1.42 to 7.89)	2.36* (1.14 to 4.89)	2.16* (1.10 to 4.24)	2.03* (1.04 to 3.95)	
Housing Instability					
Non-OUD	1.03 (0.80 to 1.31)	0.95 (0.72 to 1.25)	1.00 (0.75 to 1.33)	0.93 (0.69 to 1.27)	0.71
OUD	1.32 (0.92 to 1.89)	0.95 (0.58 to 1.54)	0.94 (0.58 to 1.53)	0.86 (0.52 to 1.43)	
1+ Physician Office Visit					
Non-OUD	1.18*** (1.08 to 1.30)	1.08 (0.97 to 1.20)	1.02 (0.91 to 1.15)	1.03 (0.91 to 1.16)	0.48
OUD	1.10 (0.93 to 1.30)	1.11 (0.91 to 1.35)	0.94 (0.77 to 1.14)	0.86 (0.69 to 1.07)	
1+ Screened-In Child Welfare Maltreatment Report					
Non-OUD	0.78 (0.24 to 2.56)	1.22 (0.40 to 3.74)	0.94 (0.30 to 2.95)	2.04 (0.49 to 8.46)	0.94
OUD	0.86 (0.06 to 12.87)	1.96 (0.16 to 24.15)	2.47 (0.20 to 31.07)	2.39 (0.13 to 44.34)	

**p < .05 **p < .01 ***p < .001*

Table A9: Estimated marginal means and relative risk ratios for GEE difference-in-differences models of the impact of having at least one PRS session on SUD treatment and recovery outcomes by geography

	Estimated difference-in-differences (95% confidence intervals)				*P* value for interaction
	Baseline to 3 months	Baseline to 6 months	Baseline to 9 months	Baseline to 12 months	
1+ Non-Fatal Overdose					
Non-Metro	2.11 (0.25 to 17.57)	0.28 (0.03 to 3.00)	1.13 (0.13 to 9.61)	1.47 (0.15 to 14.38)	0.64
Metro	0.90 (0.42 to 1.92)	0.74 (0.34 to 1.61)	1.45 (0.58 to 3.65)	1.39 (0.60 to 3.22)	
Inpatient Treatment Admission					
Non-Metro	1.23 (0.67 to 2.26)	0.92 (0.54 to 1.56)	0.78 (0.49 to 1.25)	0.86 (0.55 to 1.34)	0.14
Metro	1.09 (0.65 to 1.84)	1.37 (0.90 to 2.08)	1.23 (0.85 to 1.79)	1.23 (0.87 to 1.73)	
Outpatient Treatment Completion					
Non-Metro	2.21 (0.98 to 4.96)	1.91 (0.96 to 3.81)	1.66 (0.90 to 3.09)	1.70 (0.95 to 3.06)	0.86
Metro	2.44* (1.36 to 4.37)	1.71* (1.05 to 2.79)	1.65* (1.05 to 2.59)	1.57* (1.02 to 2.41)	
Housing Instability					
Non-Metro	0.97 (0.67 to 1.40)	0.66 (0.41 to 1.05)	0.55* (0.32 to 0.92)	0.59 (0.35 to 1.01)	0.15
Metro	1.16 (0.92 to 1.47)	1.07 (0.81 to 1.42)	1.17 (0.88 to 1.55)	1.04 (0.77 to 1.41)	
1+ Physician Office Visit					
Non-Metro	1.20** (1.05 to 1.38)	1.01 (0.87 to 1.17)	0.86 (0.73 to 1.02)	0.92 (0.77 to 1.10)	0.051
Metro	1.13* (1.02 to 1.25)	1.14* (1.01 to 1.29)	1.10 (0.97 to 1.25)	1.03 (0.90 to 1.18)	
1+ Screened-In Child Welfare Maltreatment Report					
Non-Metro	0.50 (0.11 to 2.28)	1.93 (0.51 to 7.26)	1.65 (0.43 to 6.30)	2.34 (0.54 to 10.22)	0.77
Metro	0.74 (0.17 to 3.13)	0.84 (0.21 to 3.32)	0.71 (0.17 to 2.93)	0.90 (0.10 to 8.29)	
**p < .05 **p < .01 ***p < .001*					