Effects of contingency management and use of reminders for drug use treatment on readmission and criminality among young people: A linkage study of a randomized trial

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ABSTRACT

Introduction: An increasing number of adolescents and emerging adults are entering treatment for drug use disorders in high-income countries. This fact points not only to a need to evaluate treatment outcomes related to drug use reduction, but also to evaluate other indicators of treatment success. The aim of this study was to examine treatment effects on predicting readmission to drug use treatment and being convicted for a criminal offence among youth. A second aim was to examine whether a psychiatric history had an impact on these outcomes.

Methods: Participants were 460 youth aged 15–25 who took part in the YouthDAT, a randomized pragmatic clinical trial for outpatient drug use treatment. The trial compared four treatment conditions consisting of 12 sessions of a manualized treatment based on cognitive behavioral therapy and motivational interviewing. Condition one was the standard (only the manual); condition two consisted of standard treatment and contingency management (CM) (Vouchers); condition three included standard treatment, text reminders, and low-intensity aftercare (Reminders + LIA); and condition four combined the standard treatment, CM, text reminders, and low-intensity aftercare (Combined + LIA). The study linked participants to register data on psychiatric history, drug use treatment history, and criminal convictions.

Results: Treatment conditions Reminders + LIA ($a_B = 0.42, p = .026$) and Combined + LIA ($a_B = 0.69, p = .000$) predicted longer time to readmission compared to standard treatment. The Vouchers condition predicted a lower risk for criminal convictions ($aIRR = 0.26, p = .001$). Half of the participants had a psychiatric history. The treatments with additional strategies were useful in delaying readmission and reducing convictions for these youth. The results remained significant in the adjusted models accounting for relevant participant characteristics.

Conclusions: Additional treatment strategies in outpatient drug use treatment, such as CM, text reminders, and low-intensity aftercare, predicted delayed readmission to treatment and fewer legal problems. Mental health problems were common among youth. However, the treatments with additional strategies were effective with youth with a psychiatric history. Overall, while the additional strategies may be resource demanding for clinical settings, they support treatment success and may also help to decrease other public costs.

Trial registration: ISRCTN registry ISRCTN27473213.
and many patients do not achieve abstinence (Brewer et al., 2017). While the primary aim of treatment for drug use disorders (DUDs) is to decrease drug use or reach abstinence, other treatment outcomes may have important implications for youth’s short- and long-term functioning (Skogens & von Greiff, 2020), such as readmission to treatment or criminal behavior (Luchansky et al., 2006).

A useful outcome for program evaluation is whether an individual needs additional treatment, whether for DUD specifically, or substance use disorder (SUD) more broadly (Peterson et al., 1994). Readmission to DUD treatment can be a general indicator of continued or increased drug use after an index treatment episode, and research has used it widely as an outcome of treatment for DUD (Hansen et al., 2020; Hutchison et al., 2019; Luchansky et al., 2006). At the same time, various factors may affect readmission to any type of treatment. For instance, patients in general hospitals (Carter et al., 2018) and mental health services (Druss et al., 1999) who report higher satisfaction with treatment are less likely to be readmitted. In the context of SUD, adults with a history of psychiatric diagnoses (Grahn et al., 2014) or psychiatric treatment (Hansen et al., 2020) are more likely to be readmitted to SUD treatment.

The role of psychiatric history on the impact of treatment for substance use is particularly relevant among youth, as psychiatric problems are highly prevalent among youth receiving treatment for SUD (Skogens & von Greiff, 2020). However, the majority of studies examining readmission after SUD treatment are broad and analyze any type of treatment received or focus on adults (Bockmann et al., 2019; Hutchison et al., 2019; Moreno et al., 2019; Rowell-Cunsolo et al., 2020). As a result, we know little about how a specific treatment episode for SUD predicts readmission to subsequent treatment among youth, and whether psychiatric comorbidity may affect treatment outcomes.

Another central outcome of treatment for SUD is reduction of criminal behavior. Criminal behavior is often linked to substance use (Guimaraes et al., 2017; Gustavson et al., 2007; Stahlberg et al., 2017), particularly among individuals who develop substance use problems at an early age (Gustavson et al., 2007; Stahlberg et al., 2017), and adolescents (Piana et al., 2016) and adults (Brennan et al., 2000; Sariaslan et al., 2020) with elevated psychiatric symptoms or disorders. Decreasing illegal activities among youth may have important benefits given that a criminal record has adverse effects on one’s life opportunities (Lageson, 2016).

Early studies suggested that SUD treatment is associated with crime reduction among youth (Cuellar et al., 2004; Luchansky et al., 2006). In Luchansky’s et al. (2006) study, adolescents treated for substance use who completed the recommended treatment had lower risk for both readmission and criminal recidivism than those who did not complete SUD treatment. Further, longer treatment exposure was related to lower risk for readmission. However, the evidence from observational studies is equivocal, as other factors can confound the relationship between treatment effects and criminality.

Last, treatments that reduce readmission rates, criminality, or both may translate into a financial benefit for the public system, by reducing costs related to crime (Burdon et al., 2001; Wickramasekera et al., 2015) or costs of multiple treatment readmissions (Luchansky et al., 2006). However, the field needs controlled studies that assess whether specific treatments for youth’s substance use in general, and drug use in particular, can influence criminal behavior or readmission to treatment more directly.

1.1. Drug use treatment for youth in Denmark

In Denmark, youth enter treatment for DUD primarily because of cannabis use problems. In 2017, patients receiving their first treatment for cannabis use were on average 24 years old at time of admission (EMCDDA, 2017). Of the patients receiving treatment for drug use, 60% are readmissions (EMCDDA, 2017), suggesting that many young individuals will return to treatment for DUD. Therefore, advancing treatments for drug use is important for this age group.

In a recent randomized control trial (RCT), the YouthDAT, we examined the effects of four treatment conditions in outpatient drug use treatment for Danish youth aged 15–25 (Pedersen et al., 2021). All four treatment conditions included cognitive behavioral therapy (CBT) and motivational interviewing (MI). However, three conditions varied regarding additional strategies for increasing retention (given vouchers and sending text reminders for appointments), offering optional low-intensity aftercare (LIA), or a combination of these. We found that the treatments combining vouchers and text reminders resulted in the best treatment retention rate (Pedersen et al., 2021), in line with previous studies (e.g., Fitzsimons et al., 2015).

Employing data from that trial, our primary aim in the current study was to examine whether the treatment conditions that included additional strategies also had an effect on treatment readmission and criminal behavior. We hypothesized that participants receiving enhanced treatment would have a lower risk for readmission to treatment and for accruing criminal convictions after starting the trial compared to participants receiving a standard treatment without additional strategies. A secondary aim of this study was to conduct exploratory analyses on whether these two outcomes would differ depending on psychiatric history. To address our aims, we conducted secondary analyses of the trial by linking participants to national data registers.

2. Methods

2.1. Study population

The YouthDAT was a pragmatic RCT (Zwarenstein et al., 2008) implemented between September 2014 and May 2016 in nine municipal drug use treatment centers offering public and free outpatient services for youth in Denmark. Among others, the RCT examined the effect of four treatment conditions for increasing retention among youth receiving treatment for drug use problems. All conditions included a primary treatment of 12 weekly sessions following a manual with CBT and MI. The conditions differed regarding specific additional strategies. The first condition was a CBT and MI manualized treatment without any additional elements between sessions (hereafter Standard). The remaining three conditions incorporated additional strategies as follows: Condition two included a contingency management (CM) program in which participants received vouchers (i.e., gift cards) for attending every other session (hereafter Vouchers). The third condition consisted of sending text reminders of the session appointments, as well as the possibility of receiving LIA (e.g., sporadic in-person sessions and phone conversations) after the primary treatment for up to six months (hereafter Reminders + LIA). The last condition offered a combination of CM, text reminders, and LIA (hereafter Combined + LIA). The vouchers were worth approximately €27 or US$30 each. Participants in both the Reminders + LIA and Combined + LIA conditions received on average 2.2 months of LIA, during which they received on average of 1.6 in-person sessions and 1.9 telephone contacts.

Inclusion criteria included being 15–25 years old, seeking treatment for a non-opioid drug use problem, and having used drugs within the last two months. Exclusion criteria included an inability to maintain a conversation for 30 min as indicated by a clinician’s evaluation, severe cognitive impairment, and displaying threatening behavior. Having a mental health disorder was neither an inclusion or exclusion criterion. However, the study excluded participants who were currently psychotic or aggressive. In total, the study randomized 460 young people to the four treatment conditions. This sample size was sufficient for conducting the analyses reported in Pedersen et al. (2021). Pedersen et al. (2021) describe in detail the randomization procedures and participant flow in the trial.

2.2. Registers and data preparation

We employed various population-based national registers to obtain
data for the current study. The Drug Users in Treatment register (DUT; Pedersen et al., 2013) contains dates and location for admissions and discharge from drug use treatment, as well as demographic characteristics of the patients and primary drug. The treatments recorded in the register refer to inpatient and outpatient service delivered by treatment centers, and do not include peer-support groups or attendance to Narcotic Anonymous. The Danish National Crime Register (DNCR) contains data on the type and date of reported criminal offences, as well as convictions and imprisonments. Research has described the register as one of the most thorough and comprehensive registers of its kind in Europe and North America (Wolfgang, 1977). The Danish National Patient Registry – Psychiatry (DNPPsych; Lynge et al., 2011) contains data on the duration and type of psychiatric treatment received (e.g., outpatient, inpatient) as well as the diagnoses related to the treatments. Last, the Danish National Prescription Registry (DNPres; Pottegård et al., 2017) contains information on prescription medications that a physician issued and a patient retrieved.

2.2.1. Drug use treatments

We identified distinct treatment episodes for drug use before and after the YouthDAT via the DUT. Register data from one municipality (n = 66) were not available in the DUT register, and thus we excluded them from the readmission analyses. For the remaining municipalities, we employed a 30-day gap between the recorded dates of admission to identify treatment episodes before and after the trial (see Luchansky et al., 2000 for a similar method). The study considered both outpatient and inpatient admissions. We dummy coded any treatment episode prior to YouthDAT (0 = no prior treatment; 1 = prior drug use treatment). For any readmissions after starting the trial, the observation period (i.e., time to readmission) started from the date of the last treatment session that was part of the primary treatment in YouthDAT and ended December 31, 2018 (last date available in our register data). Thus, the observation period for readmission was variable for each participant. We identified participants who either died or emigrated during the observation period. For these participants, we capped the observation period at the time of death or July 1 of the migration year, respectively. We selected half of the year as a proxy, as the exact date of migration is not registered. The study censored participants who were not readmitted during the observation period.

2.2.2. Criminal convictions

The minimum age of criminal responsibility in Denmark is 15 years. Therefore, crimes committed by an individual before this age are not in the DNCR. Offences considered for the current study fell under the following categories: property offences, trafficking of illicit substances, possession of a dangerous weapons, violent offences (including sexual), and driving under the influence of drugs or alcohol. We counted lifetime offences that led to convictions before treatment (0 = no prior convictions; 1 = conviction history), and after a minimal exposure to treatment lasting 30 days after randomization. The time for the total number of convictions used as a dependent variable started after the minimal exposure period and continued for 18 months (540 days) for all participants, unless they either died or emigrated after starting the trial. For these participants, the study capped the observation period as explained previously.

2.2.3. Psychiatric history

The study operationalized lifetime psychiatric problems as having any psychiatric diagnosis excluding substance use disorders (DNPPsych register), or as having received psychiatric treatment including psychotropic medication (DNPPsych and DNPres registers) at any point prior to participating in the trial. By merging these two registers, we formed a dummy variable of psychiatric history (yes = 1; no = 0).

2.3. Variables and statistical analyses

2.3.1. Outcomes, predictors, and covariates

The outcomes were time to readmission to drug use treatment after the last primary session of the YouthDAT, and number of convictions after minimal exposure to treatment. We conducted separate analyses for these two outcomes, as we explain. For both outcomes, the main predictor was the four treatment conditions. The study assessed all participants with the YouthMap battery (Pedersen et al., 2017) before starting treatment. The YouthMap covers current self-reported substance use, past and current self-reported behavioral problems and psychological symptoms, stressful life events, and peer and family relationships.

Covariates included sex, age, being born in Denmark (vs. not), drug use at baseline, prior treatment for drug use, history of convictions, and psychiatric history at baseline. The study assessed baseline drug use with the number of self-reported cannabis use days 30 days prior to randomization, as well as any use of illicit drugs other than cannabis 30 days prior to randomization. The study team obtained the majority of the covariates via the YouthMap, whereas others were register-based (e.g., immigration status, history of convictions, psychiatric history).

2.4. Ethics

The study team conducted the trial in accordance with the Declaration of Helsinki (World Medical Association, 2018) and the Danish Data Protection Agency and the Regional Committee for Medical and Health Research Ethics for the Central Denmark Region (#1-10-72-177-14) approved the study. In Denmark, parents or legal guardians of youth under 18 years of age must always be informed about activities in which their youth enroll. However, the Ethics Committees for Medical and Health Research Ethics decide whether a signed informed consent is required, depending on the study's aim and design. This study, then, informed parents about the research if participants were between 15 and 17 years of age. Each participant signed an informed consent form.

2.5. Statistical analyses

Both the main analyses predicting time to readmission and number of convictions, as well as supplementary models exploring moderation effects by psychiatric history, employed the full ITT sample (McCoy, 2017). We employed Stata v. 16 to analyze the data, which Denmark Statistics stored within a secure server.

2.5.1. Time to readmission

The study team conducted predictive survival analyses with time to readmission as the outcome variable. The study used the Kaplan-Meier approach to describe the survival functions of the participants (Bland & Altman, 1998). The study compared the effect of the four treatment conditions by using Cox Proportional Hazard models and Accelerated Failure Time (AFT) models. While medicine and social sciences widely use the Cox regression model, AFT models differ in their approach to assessing time to events. The Cox model assumes that the hazards associated with covariates are proportional to the time of observation (i.e., that any covariate has a multiplicative effect in the hazards function that is constant over time). In contrast, the AFT models focus on the time to an event, and test whether a given covariate accelerates (or delays) the time to the event (Chung-Hsien Chau et al., 2017; Lohman et al., 2018).

We conducted simple AFT models for each of the independent variables (treatment conditions) and covariates, as well as a final fully adjusted multiple AFT model. First, we built a simple model to be fitted employing the treatment conditions as independent variable, upon which we built the final multiple model. For the simple model, we fitted and compared various crude time-to-event models with the four treatment conditions. A log-normal distribution model was the best-fitting...
model based on the analysis of the treatment conditions according to the lowest Schwartz Bayesian Information Criterion (BIC) (Vrieze, 2012). The BIC is a criterion for model selection among a finite set of models, in which the model with the lowest BIC is preferred. BIC is partly based on the likelihood function, and it is closely related to the Akaike information criterion (AIC), but unlike the AIC, the BIC penalizes more complex models (Vrieze, 2012). Following this model, we conducted the other simple models for each of the planned covariates (sex, age, Denmark born vs. not, cannabis use days, other illicit drug use, psychiatric history, drug use treatment history). We clustered data by municipality in all models.

In the next step, we built a final adjusted multiple model. We forced the main independent variable (treatment condition) and all covariates into the multiple adjusted model to avoid problems associated with stepwise inclusion of covariates (Harvich & Tsai, 1990). We report results from both the simple and multiple AFT models with unstandardized coefficients (B), as the Stata does not allow for standardized coefficients for this type of statistical model.

2.5.2. Criminal convictions

We examined the effect of the treatment conditions on number of convictions by employing count regression models. Similar to the method employed for readmissions, we evaluated various models including Poisson regression, negative binomial regression, zero-inflated Poisson regression, and zero-inflated negative binomial regression. The best fitting simple model for criminal convictions (i.e., based on treatment conditions only) was the negative binomial regression model. This model had the best fit as indicated by the lowest BIC (Pho et al., 2019). We conducted the remaining simple models for the covariates. Last, the fully adjusted multiple model included the independent variable, and the following covariates: sex, age, Denmark born vs. not, cannabis use days, other illicit drug use, psychiatric history, previous treatment, and conviction history as covariates. We report the effects of the simple and multiple adjusted model via incremental risk ratios (IRR) and adjusted incremental risk ratios (aIRR) (Lenz & Sahn, 2020), respectively. As a supplementary analysis, we report mean number of convictions by treatment condition with 95% Poisson confidence intervals (CIs).

Further, in a sensitivity analysis, we examined the effects of the treatment conditions on time to first conviction after completing the treatment, as opposed to the 30-days of minimal exposure. Note, however, that this analysis is not directly comparable to the main analyses, since more variability occurred in the duration of the observation period from one treatment condition to another due to participants attending a different number of sessions during the treatment.

2.5.3. Exploratory moderating analyses

We conducted exploratory analyses testing a potential interaction between psychiatric history and the effect of treatment conditions. We tested these effects in adjusted multiple models employing the same covariates as the main analyses outlined above.

3. Results

3.1. Participants

Table 1 shows descriptive statistics of the ITT sample (N = 460), as well as subgroups of participants who were readmitted or convicted after randomization.

3.1.1. Baseline characteristics

The participants’ median age was 20 years (inter-quartile range [IQR] = 5 years), the majority were men and used cannabis. Among the cannabis users, the median cannabis use days was 20 days in the past 30 days prior to trial randomization (IQR = 22 days). A third of the participants used any illicit drug other than cannabis in the 30 days prior to randomization. Thirty-eight percent of participants had a lifetime psychiatric diagnosis, whereas 42% had used psychotropics in their lifetime. The most prevalent lifetime diagnoses in this sample were behavioral disorders (e.g., ADHD) (25%) followed by anxiety disorders (18%). The most frequently used prescriptions were for antipsychotics (25%) followed by psychostimulants (20%). When combining psychiatric diagnoses and use of psychotropic medication, nearly half of the sample had a psychiatric history upon randomization. A minority of the participants had prior treatments for drug use.

Approximately half of the participants had a lifetime history of convictions upon randomization (Table 1). The most frequent prior convictions were for property crimes, such as theft or burglary (39%) and violence (18%), including sexual assault and possession of illegal weapons.

The study found no differences between treatment conditions upon randomization regarding cannabis use days, any use of other drugs, prior drug use treatment, psychiatric history, and criminal convictions, p > 0.050. See Table ISM in supplementary materials for participants'
3.2. Readmission to treatment

In all, 146 (34%) participants were readmitted to treatment for drug use during the observation period (median time to readmission = 3.9 years). Table 1 presents descriptive statistics for participants who were readmitted or not for drug use treatment during this period.

3.2.1. Prediction of time to readmission

Table 2 shows the predictive simple and multiple models for readmission. (See Table IISM for model fit parameters). In the simple models, the Reminders + LIA and Combined + LIA conditions were related to longer time to readmission, whereas female sex and psychiatric history were related to a shorter time to readmission. Likewise, in the multiple adjusted model, the Reminders + LIA and Combined + LIA conditions were associated with a longer time to readmission (median 3.7 years and > 4 years, respectively) compared to the Standard treatment condition (median 2.9 years) (see Fig. 1 upper panel). Further, both female sex and prior psychiatric history were associated with shorter time to readmission (psychiatric history, median time to readmission = 3.7 years; no history, median = 3.6 years) (see Fig. 1 lower panel). Other covariates, such as being born in Denmark (vs. not), baseline cannabis use days, use of other illicit drugs, and conviction history, were not significant in either the simple or the multiple models.

3.2.2. Annual readmissions rate and exploratory analyses with psychiatric history

We estimated the annual rates of readmission for each treatment group. The highest annual rate of readmission was among participants undertaking the Standard treatment (see Table 3).

As a means to explore the role of psychiatric history in readmission, we conducted supplementary exploratory analyses examining whether psychiatric history moderated the effects of the treatment conditions. For this analysis, we conducted an additional survival analysis with the treatment condition and psychiatric history interaction. The interactions between each treatment condition and psychiatric history were not significant (p > 0.10; data not shown), thus a moderating effect of psychiatric history was not supported.

3.3. Criminal convictions

The models predicted the total number of convictions during the 18-month observation period. For descriptive purposes only, we grouped the participants with convictions as follows: 34 (7%) of the participants had convictions.

Table 3 shows the predictive simple and multiple models for convictions. In the simple models, the Vouchers condition was associated with lower risk for convictions compared to the Standard condition, whereas the other conditions were not significant. In the adjusted multiple analysis, Wald $\chi^2(10) = 77.9, p < .001$, the Vouchers, Reminders + LIA, and Combined + LIA conditions were significantly associated with lower risk for convictions. In both the simple and multiple models, female sex and younger age were also associated with lower risk for convictions, whereas using illicit drugs other than cannabis and prior convictions were associated with a higher risk for convictions.

3.3.1. Prediction of convictions

Table 4 shows the simple and multiple predictive models for convictions (See Table IISM for fit parameters). In the simple analyses, the Vouchers condition was associated with lower risk for convictions compared to the Standard condition, whereas the other conditions were not significant. In the adjusted multiple analysis, Wald $\chi^2(10) = 77.9, p < .001$, the Vouchers, Reminders + LIA, and Combined + LIA conditions were significantly associated with lower risk for convictions. In both the simple and multiple models, female sex and younger age were also associated with lower risk for convictions, whereas using illicit drugs other than cannabis and prior convictions were associated with a higher risk for convictions.

3.3.2. Annual convictions and exploratory analyses with psychiatric history

We obtained the mean number of annual convictions per participant in each treatment condition to facilitate comparison of the treatment effects between conditions (see Table 3). The Standard condition had the highest number of annual convictions; Vouchers had the lowest.

Psychiatric history was not significantly associated with the number of convictions in the main convictions model. However, we conducted exploratory analyses to address our question of whether psychiatric history could affect the outcome of the different treatment groups. The treatment conditions and psychiatric history interactions were not significant (p > 0.09; data not shown).

3.3.3. Sensitivity analyses

In an alternative model, we assessed the time from discharge from treatment (last session attended to) to first offence after that point, as opposed to after the 30-days of minimal treatment exposure. For this analysis, the best-fitting model was an accelerated failures log-normal regression analysis. In the simple model, both the Vouchers ($B = 0.90, p = .046$) and the Combined + LIA ($B = 1.04, p = .021$) conditions were associated with a delayed risk for convictions compared to the Standard condition. In the fully adjusted multiple model, the three treatments with additional strategies were associated with a longer time to convictions compared to the Standard condition (Vouchers: $aB = 1.01, p = .011$; Reminders + LIA: $aB = 0.83, p = .034$; Combined + LIA: $aB = 1.08, p = .006$).

4. Discussion

This study has two primary findings. The treatment conditions that incorporated additional strategies predicted delayed readmission and fewer convictions compared to the Standard treatment. However, the specific strategies that had a positive impact on each outcome were different. Second, having a psychiatric history was associated with a shorter time to readmission after the trial, but not with the number of

Table 2

<table>
<thead>
<tr>
<th>Simple Models</th>
<th></th>
<th>Multiple Adjusted Model</th>
</tr>
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<tbody>
<tr>
<td>Treatment Group (Standard – Reference)</td>
<td>B</td>
<td>p</td>
</tr>
<tr>
<td>Vouchers</td>
<td>0.24</td>
<td>0.248</td>
</tr>
<tr>
<td>Reminders + LIA</td>
<td>0.43</td>
<td>0.023</td>
</tr>
<tr>
<td>Combined + LIA</td>
<td>0.70</td>
<td>0.000</td>
</tr>
<tr>
<td>Female</td>
<td>-0.36</td>
<td>0.008</td>
</tr>
<tr>
<td>Age</td>
<td>0.04</td>
<td>0.300</td>
</tr>
<tr>
<td>Non-Denmark born</td>
<td>0.20</td>
<td>0.692</td>
</tr>
<tr>
<td>Cannabis Use Days</td>
<td>0.01</td>
<td>0.549</td>
</tr>
<tr>
<td>Other Drug Use</td>
<td>-0.26</td>
<td>0.188</td>
</tr>
<tr>
<td>Previous DUT</td>
<td>-0.19</td>
<td>0.429</td>
</tr>
<tr>
<td>Convictions Hx</td>
<td>-0.24</td>
<td>0.002</td>
</tr>
<tr>
<td>Psychiatric Hx</td>
<td>-0.44</td>
<td>0.035</td>
</tr>
</tbody>
</table>

$aB$ = adjusted unstandardized regression coefficient. B = unstandardized regression coefficient. CI = Confidence Interval. DUT = Drug Use Treatment. Hx = History. Negative, LIA = Low-intensity aftercare. Coefficients indicate a negative association with time to readmission (i.e., shorter time to readmission), whereas positive and larger coefficients indicate longer or delayed time to readmission.
criminal convictions during the observation period.

The two treatment conditions that incorporated text reminders for the session appointments as well as the possibility for LIA (Reminders and Combined conditions) were both associated with a readmission delay of approximately one year compared to the Standard treatment. Of these two conditions, the Combined + LIA treatment, which also included CM for treatment attendance, had the best results for delaying readmission. Therefore, one potential interpretation of our findings may be that a greater effort from treatment services to retain participants during the primary treatment combined with an LIA contact with treatment services was essential for delaying readmission.

Research examining treatment characteristics that predict readmission to substance or drug use treatment is scarce and mixed (Grella et al., 2003; Luchansky et al., 2006), making it difficult to draw direct connections between the current findings and existing evidence. However, our results are in line with findings indicating that treatment episodes of more than 90 days are linked to lower likelihood for readmission compared to shorter treatments among adolescents (Luchansky et al., 2006), and that continued care that includes aftercare programs reduces the likelihood for readmission to residential treatments (Hutchison et al., 2019; Spear, 2014). The results in our study add to these findings by showing that offering LIA may delay readmission among youth after outpatient treatment for drug use.

We found that the three treatments with additional strategies predicted fewer criminal convictions after starting treatment. Sensitivity analyses employing a different observation period reinforced the

### Table 3
Annual readmission rates per treatment group and annual number of convictions per patient per group.

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Annual Readmission Rate per Group</th>
<th>Annual Number Convictions per Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>23.2%</td>
<td>0.84 0.70, 1.01</td>
</tr>
<tr>
<td>Vouchers</td>
<td>16.3%</td>
<td>0.31 0.22, 0.42</td>
</tr>
<tr>
<td>Reminders + LIA</td>
<td>14.2%</td>
<td>0.43 0.33, 0.56</td>
</tr>
<tr>
<td>Combined + LIA</td>
<td>11.5%</td>
<td>0.42 0.32, 0.54</td>
</tr>
</tbody>
</table>

CI = Confidence Interval. Hx = History. LIA = Low-intensity aftercare.

![Fig. 1. Survival estimates of the effect of the treatment groups (upper panel), and psychiatric history (lower panel) on time to readmission to drug use treatment.](image-url)
findings that the enhanced treatment conditions were superior relative to the Standard treatment in decreasing criminal convictions by delaying the time to first conviction after discharge from SUD treatment. From our findings we cannot discern entirely what strategies were critical for reducing the risk for convictions. However, a likely explanation is that CM was a more effective strategy for reducing convictions. The two treatments that employed CM (Vouchers and Combined) had a larger effect on reducing convictions compared to the condition sending reminders and offering LIA, but without CM. Further, the Vouchers condition had a more robust effect as indicated by significant results in both the simple and multiple models. That said, the findings do suggest that longer and more engaging treatments may also help to reduce criminal activity to some extent compared to the Standard treatment.

CM-based interventions have successfully reduced youths’ substance use in certain contexts, such as aftercare interventions after residential treatment (Godley et al., 2014), or in collaboration with parents (Stanger et al., 2015). Among adults, CM interventions produce some of the best results in treating drug use problems for a variety of patients (Petry et al., 2017). That said, CM have shown less promise in court-mandated treatment so far in reducing criminal behavior (Marlowe et al., 2008; Prendergast et al., 2008). However, in these two studies other contingencies were already in place by the court. Thus, giving vouchers might not have competed with these contingencies. In our sample, where nearly half of the youth had a history of convictions, we found that CM-based interventions effectively reduced convictions in voluntary public outpatient treatment centers for youth. Thus, the results are encouraging for youth with criminal behavior, even if the effectiveness of the treatment depends on a number of variables, such as the specific behaviors that are reinforced via CM or the severity of the criminal behavior (Marlowe et al., 2008).

We also examined whether an individual’s psychiatric history would be associated with the outcomes of interest. Research examining links between mental health problems and SUD treatment readmission (Grahn et al., 2014) and criminal behavior (e.g. Sariaslan et al., 2020) has focused mostly on adults. The high prevalence of psychiatric history that this study found among its participants underscores the need to conduct research with younger individuals. Unlike studies with adults (e.g., Sariaslan et al., 2020), our findings indicated that a lifetime history of psychiatric problems was not a significant predictor of number of convictions. A potential explanation for this finding is that the interplay between mental health and SUD comorbidity evolves as individuals get older, and thus mental health affects criminal behavior in a different way (Hogue et al., 2018; Maynard et al., 2015). As for readmission, in our study, youth with a psychiatric history were readmitted to drug use treatment sooner than youth with no psychiatric history, although the difference was relatively small (approx. 1.2 months earlier). These findings are in line with studies conducted with adults (e.g., Grahn et al., 2014), potentially indicating an overall pattern of service utilization or help-seeking behavior that is similar among both youth and adults with a psychiatric history.

However, in exploratory analyses, we did not find support that psychiatric history would moderate the effects of the treatment conditions. That is, the two conditions with LIA were associated with a delayed readmission to a similar extent for individuals with and without psychiatric history. Similarly, the nonsignificant moderation of psychiatric history on criminal convictions suggested that the three conditions with additional strategies were related to a lower risk for criminal convictions to a similar extent for both individuals with and without a psychiatric history. Thus, when considering both outcomes, participants benefited from the treatments with additional strategies even if they had a psychiatric history. These preliminary findings are very encouraging for practitioners working in drug use treatment services where youth may have a high prevalence of comorbid psychiatric disorders. However, the findings should be interpreted with caution, as studies need to conceptually replicate the findings that include other factors related to mental health.

The findings also have several clinical implications. First, specific strategies may improve different outcomes. Therefore, a combined treatment that contains all the strategies that this trial tested may be the most robust method for targeting both readmission and criminal behavior in youth. The Combined + LIA treatment appeared to be the most robust for patients with a psychiatric history as well. These findings suggest that treatments that actively engage participants and continue with LIA may be more effective for a wider range of youths for more outcomes. Second, while the implementation of any of these additional strategies carries a financial and infrastructural cost for treatment settings, in countries where many of the DUD treatments are publicly funded (see Pedersen et al., 2021 for a more detailed discussion), the potential for delaying treatment readmission or decreasing convictions may reduce other costs at a system level (e.g., legal system, SUD treatment, medical treatment). Relatedly, clinic-specific analyses could reveal whether the implementation of voucher-based CM is a cost-effective solution (Olmstead et al., 2007). Last, given the increasing admission rates of young individuals in drug use treatment centers in some countries, the paucity of research examining what treatments could best serve this group of individuals is remarkable.

### 4.1. Strengths and limitations

The current study had several limitations. Our findings may not generalize to youth who did not meet our inclusion criteria, such as youth who had cognitive difficulties to complete the assessments or the 30-min sessions. We did not have reliable data for previous drug use treatment and readmission for one of the municipalities due to that municipality’s technical problems with updating the treatment database. Therefore, we excluded that municipality from the readmission

<table>
<thead>
<tr>
<th>Treatment Group (Standard - reference)</th>
<th>IRR</th>
<th>p</th>
<th>95% CI</th>
<th>IRR</th>
<th>p</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vouchers</td>
<td>0.34</td>
<td>0.12</td>
<td>0.15, 0.79</td>
<td>0.26</td>
<td>0.01</td>
<td>0.12, 0.57</td>
</tr>
<tr>
<td>Reminders + LIA</td>
<td>0.58</td>
<td>0.181</td>
<td>0.26, 1.29</td>
<td>0.40</td>
<td>0.012</td>
<td>0.20, 0.82</td>
</tr>
<tr>
<td>Combined + LIA</td>
<td>0.46</td>
<td>0.058</td>
<td>0.21, 1.03</td>
<td>0.29</td>
<td>0.013</td>
<td>0.14, 0.61</td>
</tr>
<tr>
<td>Female</td>
<td>0.35</td>
<td>0.006</td>
<td>0.17, 0.74</td>
<td>0.37</td>
<td>0.014</td>
<td>0.17, 0.82</td>
</tr>
<tr>
<td>Age</td>
<td>0.88</td>
<td>0.17</td>
<td>0.79, 0.98</td>
<td>0.74</td>
<td>0.000</td>
<td>0.66, 0.83</td>
</tr>
<tr>
<td>Non-Denmark born</td>
<td>1.68</td>
<td>0.049</td>
<td>0.38, 7.48</td>
<td>3.23</td>
<td>0.077</td>
<td>0.89, 11.77</td>
</tr>
<tr>
<td>Cannabis Use Days</td>
<td>0.98</td>
<td>0.268</td>
<td>0.96, 1.01</td>
<td>0.99</td>
<td>0.486</td>
<td>0.97, 1.02</td>
</tr>
<tr>
<td>Other Drug Use</td>
<td>2.51</td>
<td>0.003</td>
<td>1.36, 4.61</td>
<td>3.66</td>
<td>0.000</td>
<td>1.98, 6.77</td>
</tr>
<tr>
<td>Convictions Hx</td>
<td>6.23</td>
<td>0.000</td>
<td>3.52, 11.01</td>
<td>5.10</td>
<td>0.000</td>
<td>2.84, 9.14</td>
</tr>
<tr>
<td>Psychiatric Hx</td>
<td>1.21</td>
<td>0.519</td>
<td>0.67, 2.19</td>
<td>1.46</td>
<td>0.199</td>
<td>0.82, 2.60</td>
</tr>
</tbody>
</table>

CI = Confidence Interval. Hx = History. IRR = Incremental risk ratio. aIRR = Adjusted incremental risk ratio. Lower IRRs indicate lower risk, whereas higher IRRs indicate higher risk. LIA = Low-intensity aftercare.

Prediction of criminal convictions. Parameters for the negative binomial regression.

\[ IRR = \text{Incremental risk ratio. aIRR = Adjusted incremental risk ratio. Lower IRRs indicate lower risk, whereas higher IRRs indicate higher risk. LIA = Low-intensity aftercare.} \]
analyses. Further, participants from both the Combined + LIA and Reminders + LIA conditions continued to receive a form of intervention after the last session of primary treatment. The LIA lasted a relatively short period for the patients (two months on average); however, this additional intervention could have contributed to the delayed time to readmission found in these two treatment conditions. In addition, we did not have a control condition; therefore, our findings only describe the relative effects of the treatment with additional strategies compared to the Standard condition and lack a comparison to a control condition not receiving any treatment for drug use. Another limitation was that we only analyzed register data for offenses that led to convictions. This operationalization of criminal behavior is conservative, and thus the findings may not generalize to unreported offenses or illegal activities that are brought to the police’s attention, but where charges are dropped or the defendant was acquitted. Last, for the conviction analyses, two conditions (Reminders + LIA and Combined + LIA) only reached significance after adjusting for covariates. Thus, the adjusted results may be spurious (Lenz & Sahn, 2020).

However, several strengths also characterize this study. At least half of the patients in all treatment conditions received three or more months of treatment (Pedersen et al., 2021), which research suggests is the time needed to detect treatment effects (Fletcher & Chandler, 2014). The fact that we conducted the trial in regular outpatient treatment settings supports the ecological validity of the treatments examined. Specifically, the study shows that interventions combining a variety of strategies may be successfully implemented in a wide range of settings serving youth with drug use problems. Further, with the inclusion of four different treatment conditions, we were able to analyze the effects of different strategies in relation to the outcomes. Moreover, with the use of register data, we reduced biases related to self-reported data regarding mental health, convictions, and prior and consecutive treatment episodes for drug use. Last, by observing participants through registers, as opposed to limiting data to in-person assessments of the outcomes, we also reduced biases introduced by self-selection related to attrition for follow-up assessments and other biases associated with self-report.

4.2. Conclusion

We found robust support indicating that efforts to retain youth in outpatient treatment and low-intensity aftercare for drug use are later associated with delayed readmission to treatment and reduced incidence of criminal convictions. The findings also suggested that youth with a psychiatric history can benefit from enhanced drug use treatments even without a specific focus on psychiatric illness.

CRediT authorship contribution statement

APG: Conceptualization, Methodology (register), formal analysis, investigation (register), data curation, writing (original draft, reviewing, and editing), visualization. MH: Conceptualization, Methodology (register), formal analysis, data curation, writing (reviewing and editing), visualization. BT: Conceptualization, Methodology (register), writing (reviewing and editing), supervision, administration, funding. MMP: Investigation (trial and register), data curation, formal analysis.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsat.2021.108617.

References


