

Depression, Alcoholics Anonymous Involvement, and Daily Drinking Among Patients with co-occurring Conditions: A Longitudinal Parallel Growth Mixture Model

Noel Vest , Alex Sox-Harris, Mark Ilgen, Keith Humphreys, and Christine Timko

Background: Patients with cooccurring mental health and substance use disorders often find it difficult to sustain long-term recovery. One predictor of recovery may be how depression symptoms and Alcoholics Anonymous (AA) involvement influence alcohol consumption during and after inpatient psychiatric treatment. This study utilized a parallel growth mixture model to characterize the course of alcohol use, depression, and AA involvement in patients with cooccurring diagnoses.

Methods: Participants were adults with cooccurring disorders ($n = 406$) receiving inpatient psychiatric care as part of a telephone monitoring clinical trial. Participants were assessed at intake, 3-, 9-, and 15-month follow-up.

Results: A 3-class solution was the most parsimonious based upon fit indices and clinical relevance of the classes. The classes identified were high AA involvement with normative depression (27%), high stable depression with uneven AA involvement (11%), and low AA involvement with normative depression (62%). Both the low and high AA classes reduced their drinking across time and were drinking at less than half their baseline levels at all follow-ups. The high stable depression class reported an uneven pattern of AA involvement and drank at higher daily frequencies across the study timeline. Depression symptoms and alcohol use decreased substantially from intake to 3 months and then stabilized for 90% of patients with cooccurring disorders following inpatient psychiatric treatment.

Conclusions: These findings can inform future clinical interventions among patients with cooccurring mental health and substance use disorders. Specifically, patients with more severe symptoms of depression may benefit from increased AA involvement, whereas patients with less severe symptoms of depression may not.

Key Words: Longitudinal Growth Mixture Model, Depression, Alcoholics Anonymous Involvement, Alcohol Use, Cooccurring Patients.

OVER 9 MILLION Americans have cooccurring substance use and mental health disorders (Substance Abuse and Mental Health Services Administration, 2019) with some 58% of individuals receiving psychiatric inpatient services also reporting a lifetime diagnosis of substance use disorder (Mueser et al., 2000). Population surveys show that about one-half of people who experience a mental health disorder such as major depressive disorder during their lifetime will also experience a substance use disorder (National Institute on Drug Abuse, 2020). When individuals seek care for either condition, they can be clinically challenging, incur high

healthcare costs, and have longer lengths of stay and higher relapse rates than those with only one of these conditions (Chen et al., 2006; Drake et al., 1996; Jané-Llopis and Matytina, 2006; Kranzler and Rosenthal, 2003; Stoffelmayr et al., 1989). To inform care of this vulnerable clinical population, this study aimed to understand the unique change processes that influence longer-term outcomes among these patients after inpatient psychiatric care, including their involvement in peer mutual-help groups.

Mutual-help groups often serve as a source of primary recovery support and as an adjunct to treatment for patients with cooccurring conditions (Humphreys, 2003; Tonigan et al., 2018), with the hope that these individuals will maintain their involvement after treatment. Research suggests that people with cooccurring conditions benefit from mutual-help groups such as Alcoholics Anonymous (AA), Double Trouble, and Narcotics Anonymous, (Bogenschutz et al., 2006; Magura, 2008; Timko et al., 2013; Tonigan et al., 2018). Prospective research has shown that AA involvement (i.e., engagement in 12-step practices such as reading literature, having a sponsor, and service work) predicts declines in depression symptoms over time (Humphreys et al., 1997). Studies are needed to examine the influence of group

From the Department of Psychiatry and Behavioral Sciences, (NAV, KH, CT), Stanford University School of Medicine, Stanford, California; Veterans Affairs Palo Alto Health Care System, (AHSH, KH, CT), Palo Alto, California; Department of Surgery (AHSH), Stanford University School of Medicine, Stanford, California; Department of Psychiatry, (MI), University of Michigan, Ann Arbor, Michigan; and VA Center for Clinical Management Research (CCMR), (MI), Ann Arbor, Michigan.

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Reprint requests: Noel Vest, PhD, Systems Neuroscience and Pain Lab, 1070 Arastradero Rd. Ste 200, Palo Alto, CA 94304, USA; Tel.: 650-725-9638; Fax: 650-725-9642; E-mail: noelvest@stanford.edu

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involvement across time and document patterns of response within the heterogeneous population.

Major depressive disorder (MDD) merits special attention in discussions of cooccurring disorders because it is the most prevalent mental health disorder among individuals treated for substance use disorders (Hides et al., 2019; Hobden et al., 2018; Torrens et al., 2011) and has been associated with shorter time to relapse after treatment (Suter et al., 2011). Depression symptoms also tend to decrease, on average, over time among individuals in substance use treatment (Overall et al., 1985), including those in psychiatric inpatient care (Foulds et al., 2015). For example, in a study of 1,706 substance use disorder outpatients, depression symptom levels decreased from intake to 3 months and then were stable over the next year (Kelly et al., 2010b). Further, greater AA attendance was associated with less alcohol use and lower levels of depression. However, when alcohol use was controlled, the effect of AA participation on depression was muted, suggesting that reductions in drinking accounted for the relationship between AA participation and reduced depression (Kelly et al., 2010b). Additionally, in a study examining inpatients with SUD, with and without cooccurring MDD, Kelly and colleagues (2003) found that substance use outcomes did not differ between the groups at 1 and 2 years posttreatment. However, in a moderation analysis, the cooccurring group's probability of remission and abstinence outcomes worsened as a function of their level of 12-step mutual-help involvement at 2 years posttreatment. These findings in inpatients and outpatients treated for SUD begin to paint a picture of what may be happening to these patients posttreatment, but more research is needed to determine *when* these reductions in depression symptomatology and AA involvement may occur across time, whether these effects hold among those treated in inpatient psychiatric settings, and further, how changes in depression and AA involvement may influence daily alcohol use among those with a cooccurring condition.

Previous examinations of depression, AA involvement, and alcohol use have employed a variable-based approach that focuses on a priori categorization of these constructs. This approach includes estimating regression models in which alcohol use is modeled across time as a function of levels of depression or AA involvement. Though this approach may be informative for understanding each of these processes individually, a person-based approach (Nagin and Odgers, 2010), used in the present study, allows description of the shape of alcohol use trajectories and the influence of depression and AA involvement that are observed in the population across time. Lastly, data-derived latent classes¹ can be used to examine demographic and

other important clinical characteristics that may vary across classes.

This study used such an approach to examine the relationship among alcohol use, symptoms of depression, and AA involvement by applying a person-centered modeling technique to relate long-term trajectories. It also used the classes to examine differences on demographic characteristics and other important indicators that may differ by class membership. These included prior treatment, incarceration history, and amount spent on alcohol, which prior studies have shown are associated with outcomes among patients treated for cooccurring disorders (Najt et al., 2011; Painter et al., 2018; Watkins et al., 2016).

Accordingly, this study examined AA participation patterns, depression symptoms, and alcohol consumption among latent classes of patients with cooccurring mental health and substance use disorders who had been admitted to veteran psychiatric inpatient care. Specifically, we used parallel growth mixture modeling to simultaneously assess levels of depression symptoms, AA involvement, and daily alcohol use trajectories during and after inpatient psychiatric treatment. The aim was to inform treatment planning for patients hospitalized for cooccurring conditions by observing the course of drinking and depression symptoms over time in relation to AA involvement, including the proportion of patients who may need more intensive treatment resources after hospital discharge, and how long after discharge the need for such treatment may occur due to an increase in drinking and/or depression symptoms. The findings may also suggest the extent to which providers should refer patients to AA or to other posttreatment recovery resources to achieve benefits on alcohol use and depression symptoms.

MATERIALS AND METHODS

This was a secondary analysis of data from a randomized controlled trial that compared usual care with telephone monitoring on the primary outcomes of alcohol and other drug use and mental health symptoms among patients at 2 healthcare facilities within the Veterans Health Administration (VA) healthcare system (Timko et al., 2019). The inpatient psychiatry treatment averaged 7 days and interventions included comprehensive assessment, psychopharmacology, individual and group psychotherapy, and behavioral interventions. Patients in both conditions improved over time on each primary outcome, and improvement was comparable between conditions (Timko et al., 2019).

Participants and Study Design

The original study included 406 patients with a cooccurring diagnosis of substance use and mental health disorders as documented in the medical record. Participants completed a self-report measure at baseline and then at 3-month, 9-month, and 15-month follow-ups. Participants received \$25 for each completed assessment. Because the telephone monitoring intervention did not have a significant effect on any relevant outcomes, we collapsed the treatment and control groups across conditions. At baseline, the mean age was 44.9 (SD = 12.9), 29.6% were married, and 7.2% of participants were currently homeless. The sample was primarily male (90.0%) and Caucasian (63.1%).

¹Throughout out this paper, we refer to the analytic approach as a longitudinal parallel growth mixture model or simply growth mixture model. Importantly, this statistical approach is a type of latent class analysis with repeated measures. Hence, results are discussed in terms of latent classes or data-derived patient subgroups.

Measures

The Addiction Severity Index (ASI; McLellan, Cacciola, Alterman, Rikoon, and Carise, 2006) was used to assess participants' baseline demographic and other characteristics that are listed in Table 3. In addition, at baseline and each follow-up, the Time Line Follow Back procedure (Sobell et al., 1996), a widely used, standardized, calendar-based retrospective self-report assessment to quantify daily substance use, assessed the number days the participant used alcohol in the past 90 days. AA involvement was also assessed at baseline and each follow-up, and was the count of 14 12-step practices the participant reported having engaged in, such as reading 12-step literature, serving at meetings, and having a sponsor (Timko et al., 2017). Cronbach's alpha for the AA involvement scale at baseline, 3 months, 9 months, and 15 months was 0.87, 0.90, 0.91, and 0.92, respectively. Depression symptoms were assessed with the Patient Health Questionnaire (PHQ-9), which has excellent internal consistency and test-retest reliability and contains 9 items, each scored 0 to 3, providing a 0 to 27 severity score (Kroenke et al., 2001). Cronbach's alpha for the PHQ-9 at baseline, 3 months, 9 months, and 15 months was 0.89, 0.89, 0.91, and 0.94, respectively. Figure S1 provides a depiction of trajectories for each of the 3 variables (number of days used alcohol, AA involvement, depression symptoms) across time for each participant in the sample. Additionally, the mean for each measure is shown which illustrates the extreme variability in the model. This heterogeneity offers strong justification for growth mixture modeling of response patterns across the 15-month study period.

Data Analyses

The demographic information class probabilities and analysis of variance (ANOVA) were computed using SPSS ver. 25 (IBM Corporation, 2017). The longitudinal parallel growth mixture model (Nagin, 2005) was analyzed using MPlus version 8.2 (Muthén & Muthén, 2018). As illustrated in Fig. 1, this repeated measures growth mixture model utilized simultaneous analysis of parallel outcomes to better understand how depression and AA involvement impact alcohol use after psychiatric inpatient care. The trajectories for depression, AA involvement, and daily alcohol use are summarized by their respective intercepts and slopes. The variances of the intercepts and slopes were set to zero so the means of the growth factors (intercept and slope) were allowed to vary across factors, such that the latent classes were identified by the patterns of alcohol use, depression, and AA involvement change over time. Parallel modeling, rather than separate modeling of these processes, was preferred because the results offer a more efficient and less biased estimate of the effects across time (Olino et al., 2010; Wickrama et al., 2013).

Seven patients did not fill out study questionnaires beyond the baseline demographics data, so the final sample included 399 individuals. The follow-up rates for the study were 84%, 76%, and 77% at 3, 9, and 15 months, respectively. Age was the only demographic characteristic that was significantly different from those who were lost to follow-up and those who were not. Patients who were lost to follow-up were younger than patients not lost to follow-up (3 months: $M = 45.6$ ($SD = 12.4$) vs. $M = 41.9$ ($SD = 14.4$), $t = 2.22$, $p = 0.027$; 9 months: 46.0 (12.3) vs. 42.1 (13.7), $t = 2.84$, $p = 0.005$; 15 months: 46.1 (12.4) vs. 41.4 (13.6), $t = 3.33$, $p = 0.001$). Because covariates are not suggested in the latent class enumeration process due to problems with model convergence and overextraction (Nylund-Gibson and Masyn, 2016), we did not control for age in the modeling. However, to assure that age was not confounding the model, we ran the final 3-class model controlling for the influence of age and found that the interpretations of all outcomes were not affected. Missing data were handled with full information maximum likelihood, robust to data missing at random.

This method computes the standard covariance matrix using the entire sample.

Determining Patient Typology

The ideal number of latent classes is often determined by theoretical considerations regarding clinical relevance and prior research (Nagin and Odgers, 2010; Little, 2013). Typically, the multiclass solutions are compared statistically based upon overall model fit. The Bayesian information criterion (BIC) is a common comparison fit statistic used to characterize the number of classes in a dataset (Kass and Raftery, 1995). Along with BIC, we also examined entropy, Lo–Mendell–Rubin (LMR) likelihood ratio test, and overall interpretability of the solutions to determine the most parsimonious and clinically distinct model (Nagin and Odgers, 2010). Entropy is a measure of class membership likelihood that ranges from 0 to 1 (values closer to 1 are preferred); values above 0.80 indicate good class membership. The LMR test is a likelihood ratio test that offers a measure of the current mixture model (k) and a sample drawn with $(k-1)$ one fewer latent class (Lo et al., 2001). Models were fit for 1 through 6 latent class solutions. For each class solution, we allowed the model to estimate mean values for intercept, slope, quadratic, and cubic functions. We then examined the estimates for each value and reset the nonsignificant values to zero in a revised model. Because the new values can affect other trajectories in the model, this process was continued until all nonsignificant values had been set to zero.

Lastly, given the latent classes selected for patient typology, overall class inclusion (posterior probability) was then calculated to evaluate differences in frequency of these variables (see Table 3). An ANOVA with Fisher's least significant difference post hoc test was computed to evaluate class differences.

RESULTS

Table 1 provides the model fit indices for 1 through 6 latent class solutions. Based on fit indices, it was concluded that the 3-class revised solution was the best performing model; $AIC = 26789$, $BIC = 26933$. BIC values were lower for the 6-class model, but growth trajectories overlapped for many of the 6 classes, and extremely small class sizes made clinical interpretation impossible. The 3-class model was superior on other fit indices. This final model included 36 parameters, entropy was high at 0.88 (well above the 0.80 cutoff), the LMR was significant at 540.18, and the estimated classes were of acceptable size (61%, 27%, and 11% of the sample) as well as clinically relevant. As noted in Table 2, average latent class probabilities for inclusion in the individual classes for the 3-class solution were high at 93.7%, 93.8%, and 95.4%. That is, for example, the probability that an individual classified as being in Class 1 was classified correctly was 93.7% of the time, on average. Because the entropy was high and the class separation was good, we calculated class differences using the 2-step approach of modal class assignment (Clark and Muthén, 2009).

Figure 2 is a graphical presentation of the 3 classes over time. The following classes are defined by the most parsimonious 3-class model: (i) high AA involvement (normative depression), (ii) high stable depression (uneven AA involvement), and (iii) low AA involvement (normative depression) class. Class 1 (high AA involvement) represents a class with

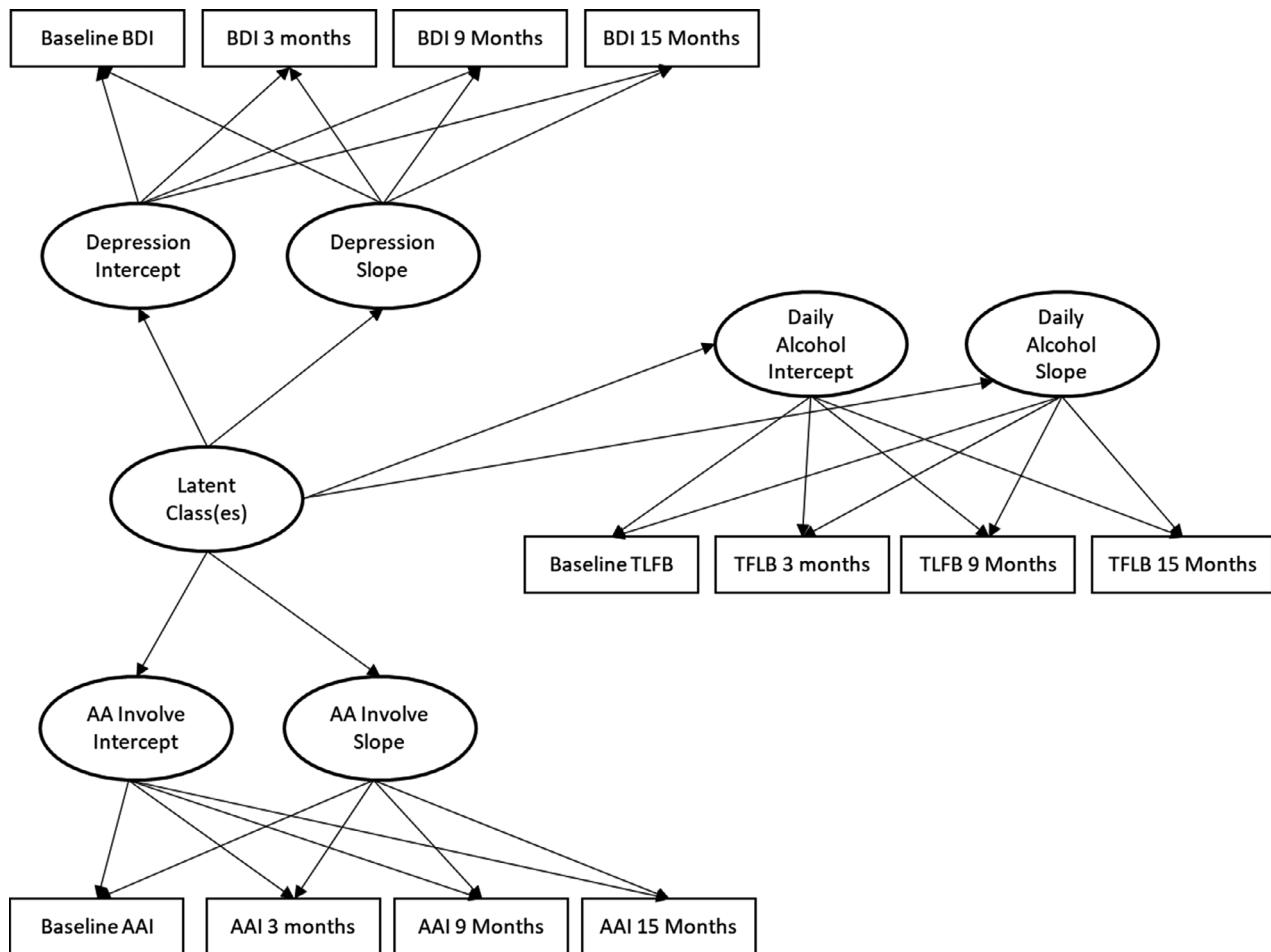


Fig. 1. A statistical diagram of the simultaneous parallel growth mixture model. Though not pictured for sake of simplicity, potential quadratic and cubic equations were estimated for each outcome. All intercepts were set to 1 and slopes set from 0 to 3 for each outcome.

high and consistent AA involvement, normative (defined as an initial decrease followed by a leveling off across time) alcohol use, and a normative depression (defined as an initial decrease in depression from baseline to 30 days followed by a leveling off across time) trajectory (blue lines in Fig. 2; $n = 109$, 27.3%). Class 2 (high depression) was characterized by high stable depression, low AA involvement, and high alcohol use (orange lines in Fig. 2; $n = 42$, 10.5%). Class 3 (low AA involvement) represents a low AA involvement, typical depression, and typical alcohol use class (gray lines in Fig. 2; $n = 248$, 62.2%). Two of the classes (high AA and low AA) each demonstrated similar trajectories for depression and alcohol use, yet differed from each other in their AA involvement. Both of the AA classes decreased their daily drinking levels substantially by the end of the 15-month follow-up. In contrast, the high depression class appeared to be the most unstable regarding AA involvement across the study period, with no decrease in depression and a high, yet stable, level of drinking.

Table 3 shows the most likely class membership (posterior probabilities) for key demographic variables and other outcomes of interest among the sample. Using ANOVA

statistical tests, when compared to the low AA class, the high AA class had significantly more previous outpatient treatment episodes and more months of incarceration. The high depression class reported that they continued drinking though it worsened mental or physical health problems when compared to the low and high AA classes (which did not differ significantly from each other). The high depression class also reported more money spent on alcohol in the past 30 days than the low AA class.

DISCUSSION

To our knowledge, this is the first study to examine the parallel change trajectories of AA involvement, depression, and alcohol use among patients with cooccurring conditions. These findings contribute to the literature on AA involvement among individuals with cooccurring disorders. Previous work has evaluated the influence of AA involvement on drinking outcomes, but this is the first to empirically classify individuals into patient classes based on outcome trajectories. The results highlight multiple paths to recovery, some involving AA and some not. This is encouraging in that

Table 1. Model Fit Indices and Estimated Class Size for Growth Mixture Model

Model	AIC	BIC	Δ BIC	Class size	Entropy	LMR LRT	Par.
1 Class	27805	27901		100%			24
2 Class	27190	27388	504	71%, 29%	0.87	640.98*	37
2 Class Revised	27196	27320	68	71%, 29%	0.87	632.97*	31
3 Class	26765	26941	379	61%, 27%, 11%	0.88	443.75*	44
3 Class Revised	26789	26933	8	61%, 27%, 11%	0.88	540.18*	36
4 Class	26600	26795	138	60%, 25%, 8%, 7%	0.88	186.50	49
4 Class Revised	26681	26852	-57	40%, 27%, 23%, 10%	0.78	124.99	43
5 Class	26513	26737	115	35%, 26%, 23%, 9%, 7%	0.79	97.43	56
5 Class Revised	26509	26713	24	38%, 25%, 22%, 8%, 7%	0.79	103.83	51
6 Class	26465	26720	-7	37%, 21%, 17%, 9%, 8%, 8%	0.78	58.68	64

BIC, Bayesian information criterion; AIC, Akaike information criterion; Δ BIC, change in Bayesian information criteria; LMR LRT, Lo-Mendel-Rubin likelihood ratio test; Par., parameters in model.

Bold line indicates the model chosen as the overall best fitting class.

**p* < 0.001.

Table 2. Average Latent Class Probabilities for Most Likely Latent Class Membership (Row) by Latent Class (Column)

	1	2	3
1	0.938	0.008	0.054
2	0.009	0.937	0.054
3	0.027	0.019	0.954

many patients in this diverse population showed significant improvement on drinking while they utilized different strategies or approaches to recovery.

Almost 90% of the sample had cut their alcohol use by 50% or more by the end of the 15-month study. From a public health perspective, this constitutes a positive outcome among this patient group. Recent empirical reviews indicate that, even among those patients with established alcohol use disorders, significant reductions in alcohol use without achieving full abstinence were associated with improved long-term functional outcomes (Mann et al., 2017; Witkiewitz and Tucker, 2020). This is also consistent with epidemiological work suggesting that among individuals in remission from alcohol use disorder, the majority (61%) were not abstinent in a 3-year follow-up (Dawson et al., 2007). Across the same 15-month period, patients with cooccurring conditions in the current study also reported substantially reduced depression symptom levels. This also suggests that many individuals with cooccurring psychiatric and substance use disorders who are seen in inpatient psychiatric treatment settings report overall improvements in the primary disease outcomes (depression and alcohol consumption) following their inpatient stay.

There were several unique features of the class with high AA involvement. These individuals reported a mean of 5 previous outpatient treatment episodes, with the other classes only reporting 2 and 1 previous treatment episodes on average (Table 3). This suggests that those with multiple treatment episodes are more likely to become increasingly involved in AA over time. These findings are consistent with

previous work showing the positive relationship between baseline SUD severity and subsequent AA involvement (Bogenschutz, 2008), though the presence of a cooccurring mental health issue (Bergman et al., 2014) or more severe conditions (Timko et al., 2013) has been shown to possibly hinder mutual-help involvement. Such findings may offer insight as to why this study found lower levels of AA involvement among the high depression class. The high AA involvement class also reported long lengths of lifetime incarcerations with an overall average of 20 months, compared with 14 and 9 months in the other classes. Although future research is needed to investigate other variables that may be influencing findings for incarceration and treatment, results suggest that these institutions should continue to supplement clinical interventions with adjunctive AA meetings to facilitate AA involvement.

All 3 classes had comparable, high levels of baseline depression levels but differed in the stability of depression across time. The high and low AA involvement classes had a similar trajectory of a rapid decrease in depression scores from 0 to 3 months and then a leveling off from 3 to 15 months. This suggests that patients in these classes may have symptoms of depression which are substance-induced (Dakwar et al., 2011) and more transitory in nature. Individuals in the high depression class had inconsistent AA involvement and reported continued drinking overtime. These individuals may need an intervention to either increase AA involvement or find alternatives to AA to help reduce their alcohol use. A follow-up questionnaire inquiring about the reasons for refusal of AA involvement (Kelly et al., 2010a) would help to inform clinicians on potential barriers for this patient group. Importantly, the high depression class spent a mean of \$267 (15.6% of total income) on alcohol in the month prior to entering treatment and 93% reported that they had continued to drink alcohol despite it causing mental or physical health problems. These findings suggest that amount spent on alcohol, and alcohol use despite negative health outcomes, may offer latent measures of clinical severity for individuals with cooccurring conditions.

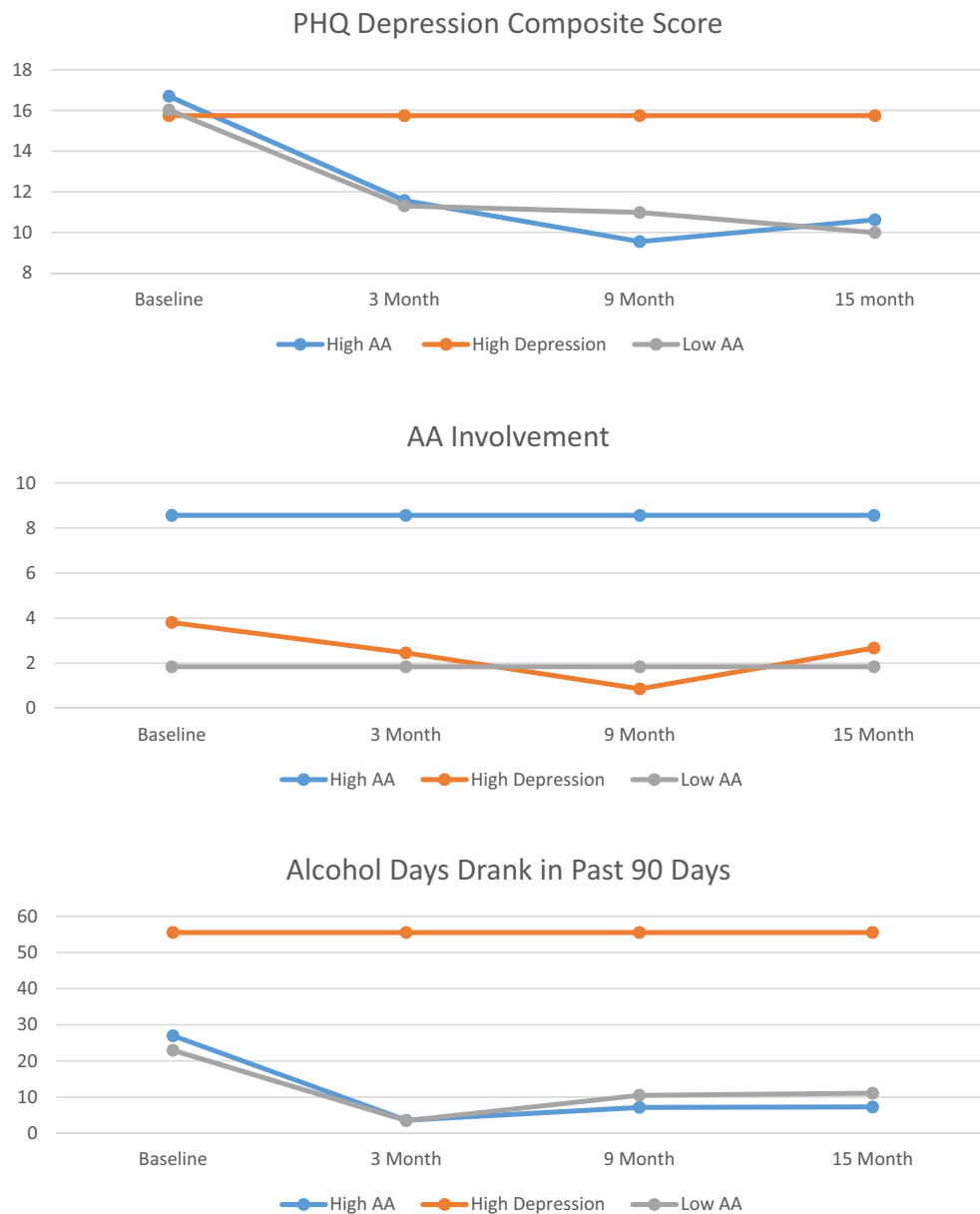


Fig. 2. Simultaneous 3-class trajectories of depression, AA involvement, and alcohol use outcomes across the 15-month study timeline. High AA $n = 109$, high depression $n = 42$, and low AA $n = 248$. AA = Alcoholics Anonymous.

This study has limitations. First, time-variant indicators other than depression, AA involvement, and daily alcohol use variables could be important for characterizing the population of patients with cooccurring disorders. For example, PTSD and AA attendance (as opposed to AA involvement) offer 2 important outcomes among this patient population that we were not able to capture with this study. Second, among clinical populations depression is most often diagnosed through structured interview. However, this study design implemented a self-report survey to measure depression symptomatology across time. This limitation is noteworthy and future research will be needed to examine the effects of AA involvement on individuals meeting diagnostic

criteria for MDD. Third, the external validity of these findings may have been impacted because younger individuals contributed less to the data in follow-up measurements throughout the 15-month study. Additionally, these data were collected through the VA, such that the patient population may not generalize to other settings. Similarly, the availability of psychiatric treatment services may be higher compared to a non-VA sample. However, systematic reviews demonstrate that VA-provided health care is similar to care provided in non-VA health systems (Trivedi et al., 2011). Fourth, we did not include other common forms of treatment (i.e., inpatient or outpatient SUD treatment) to the model which may have impacted all of the outcomes and

Table 3. Class Membership and Means for Select Baseline Demographic and Other Variables

Demographic (SD or %)	Class 1 High AA	Class 2 High Depression	Class 3 Low AA
Total Individuals in Class	109	42	248
Male Gender	98 (90%)	35 (83%)	229 (92%)
Currently Married	13 (12%)	3 (7%)	47 (19%)
White Race	62 (56%)	26 (61%)	164 (66%)
Age Mean	46.17 (12.11)	47.05 (11.51)	43.79 (10.34)
Age of First Use	13.87 (4.44)	14.69 (3.43)	14.81 (2.67)
Currently Homeless	14 (13%)	5 (12%)	34 (14%)
Average Years of Education	13.72 (1.89)	13.62 (2.64)	13.36 (3.59)
Currently Employed	48 (44%)	19 (45%)	118 (48%)
Previous Outpatient Treatment	5.55 (6.92) _a	2.29 (3.94)	1.34 (4.28) _a
Lifetime Months Incarcerated	20.01 (59.72) _a	14.45 (30.26)	8.72 (30.90) _a
Continued to Drink Even Though it Caused Mental or Health Problems	72 (66%) _a	39 (93%) _{ab}	143 (58%) _b
Total Income Past 30 Days	1,988.15 (2,123.23)	1,707.10 (1,414.67)	1,825.85 (3,572.17)
Spent on Alcohol Past 30	\$157.99 (257.43)	\$267.74 (540.56) _a	\$98.46 (303.95) _a

AA, Alcoholics Anonymous.

Subscripts with identical letters were significantly different from each other using class posterior probabilities and analysis of variance statistical tests at $p \leq 0.05$.

future investigations will be needed to examine the impact of these variables. Fifth, we chose to implement the 2-step approach (i.e., classify-analyze) to examine differences between classes despite some recommendations in the literature against such an approach (Clark and Muthén, 2009). Lastly, growth mixture modeling does not have an agreed upon “gold-standard” regarding model selection rules (Nagin and Odgers, 2010). Hence, we concluded that the 3-class model was the most parsimonious, but other researchers may wish to explain patient classes with less than 10% of the sample or incorporate a p-value on LMR values less stringent than the a priori level of 0.001. Strengths of this study include the parallel modeling of 3 clinically distinct factors and high-retention rates among this difficult-to-follow patient sample.

In conclusion, employing advanced statistical modeling and using a large clinical sample, this study found that levels of depression and alcohol use declined in a similar and predictable pattern for many patients with cooccurring conditions following psychiatric inpatient care. For a small patient group (11%) of individuals with high and stable depression severity, alternate forms of recovery support may be needed. This is an especially important finding given that AA is commonly recommended by clinicians (Humphreys, 1997). Although we are not suggesting that clinicians discontinue referrals to 12-step mutual-help organizations, they may want to broaden their efforts to include other resources, particularly for patients with high and stable depression. Mutual-help alternatives to AA may provide a better fit for patients with high and stable depression symptoms because of the programs’ different foci on how to overcome addiction including secular (Smart Recovery), Christian (Celebrate Recovery), or Buddhist (Refuge Recovery) foundations, their simultaneous focus on both mental health and substance use (e.g., Double Trouble), or their focus on mental

health (e.g., Depression and Bipolar Support Alliance). Resources may also include evidence-based treatments for cooccurring MDD and alcohol use disorder (AUD), such as integrated cognitive behavioral therapy (ICBT). Indeed, among patients with cooccurring MDD and SUD, ICBT may yield more stable clinical outcomes than twelve-step facilitation (TSF) does after treatment has ended (Brown et al., 2006; Worley et al., 2013). TSF modifications may be necessary to facilitate 12-step involvement, reduced drinking, and improved depression symptoms for patients with cooccurring AUD and MDD. Additionally, future clinical investigations may examine the role of medications for MDD and how they may impact alcohol-related outcomes among people who do and do not attend mutual-help organizations regularly.

In sum, this study identifies multiple pathways to recovery among this patient group with cooccurring disorder and offers guidance regarding AA referrals and other potential help sources for clinicians. Specifically, increased AA involvement may be helpful to those with indicators of more severe conditions and less critical for those with less severe conditions.

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CONFLICTS OF INTEREST

The authors report no conflicts of interest.

REFERENCES

- Bergman BG, Greene MC, Hoepfner BB, Slaymaker V, Kelly JF (2014) Psychiatric comorbidity and 12-step participation: A longitudinal investigation of treated young adults. *Alcohol Clin Exp Res* 38:501–510.
- Bogenschutz MP (2008) Individual and contextual factors that influence AA affiliation and outcomes, in *Recent Developments in Alcoholism* (Kaskutas L, Galanter M eds), pp. 413–433. Springer, New York, NY.
- Bogenschutz MP, Geppert CMA, George J (2006) The role of twelve-step approaches in dual diagnosis treatment and recovery. *Am J Addict* 15:50–60.
- Brown SA, Glasner-Edwards SV, Tate SR, McQuaid JR, Chalekian J, Granholm E (2006) Integrated cognitive behavioral therapy versus twelve-step facilitation therapy for substance-dependent adults with depressive disorders. *J Psychoactive Drugs* 38:449–460.
- Chen S, Barnett PG, Sempel JM, Timko C (2006) Outcomes and costs of matching the intensity of dual-diagnosis treatment to patients' symptom severity. *J Subst Abuse Treat* 31:95–105.
- Clark S, Muthén BO (2009) Relating latent class analysis results to variables not included in the analysis. *StatisticalInnovations.com*
- Dakwar E, Nunes EV, Bisaga A, Carpenter KC, Mariani JP, Sullivan MA, Raby WN, Levin FR (2011) A comparison of independent depression and substance-induced depression in cannabis-, cocaine-, and opioid-dependent treatment seekers. *Am J Addict* 20:441–446.
- Dawson DA, Goldstein RB, Grant BF (2007) Rates and correlates of relapse among individuals in remission from DSM-IV alcohol dependence: a 3-year follow-up. *Alcohol Clin Exp Res* 31:2036–2045.
- Drake RE, Mueser KT, Clark RE, Wallach MA (1996) The course, treatment, and outcome of substance disorder in persons with severe mental illness. *Am J Orthopsychiatry* 66:42–51.
- Foulds JA, Adamson SJ, Boden JM, Williman JA, Mulder RT (2015) Depression in patients with alcohol use disorders: systematic review and meta-analysis of outcomes for independent and substance-induced disorders. *J Affect Disord* 185:47–59.
- Hides L, Quinn C, Stoyanov S, Kavanagh D, Baker A (2019) Psychological interventions for co-occurring depression and substance use disorders. *Cochrane Database Syst Rev* 2019(11):CD009501.
- Hobden B, Bryant J, Carey M, Baker AL, Farrell M, Oldmeadow C, Mattick RP, Shakeshaft A, Sanson-Fisher R (2018) Finding the optimal treatment model: a systematic review of treatment for co-occurring alcohol misuse and depression. *Aust N Z J Psychiatry* 52:737–750.
- Humphreys K (1997) Clinicians' referral and matching of substance abuse patients to self-help groups after treatment. *Psychiatr Serv* 48:1445–1449.
- Humphreys K (2003) *Circles of Recovery*. Cambridge University Press, Cambridge, UK.
- Humphreys K, Moos RH, Cohen C (1997) Social and community resources and long-term recovery from treated and untreated alcoholism. *J Stud Alcohol* 58:231–238.
- IBM Corp (2017) *IBM SPSS Statistics for Windows, Version 25.0*. IBM Corp., Armonk, NY.
- Jané-Llopis E, Matysina I (2006) Mental health and alcohol, drugs and tobacco: a review of the comorbidity between mental disorders and the use of alcohol, tobacco and illicit drugs. *Drug Alcohol Rev* 25:515–536.
- Kass RE, Raftery AE (1995) Bayes factors. *J Am Stat Assoc* 90(430):773–795.
- Kelly JF, Kahler CW, Humphreys K (2010a) Assessing why substance use disorder patients drop out from or refuse to attend 12-step mutual-help groups: The "rEASONS" questionnaire. *Addict Res Theory* 18:316–325.
- Kelly JF, McKellar JD, Moos R (2003) Major depression in patients with substance use disorders: Relationship to 12-Step self-help involvement and substance use outcomes. *Addiction* 98:499–508.
- Kelly JF, Stout RL, Magill M, Tonigan JS, Pagano ME (2010b) Mechanisms of behavior change in alcoholics anonymous: Does Alcoholics Anonymous lead to better alcohol use outcomes by reducing depression symptoms? *Addiction* 105:626–636.
- Kranzler HR, Rosenthal RN (2003) Dual Diagnosis: alcoholism and comorbid psychiatric disorders. *Am J Addict* 12:s26–s40.
- Kroenke K, Spitzer RL, Williams JBW (2001) The PHQ-9: Validity of a brief depression severity measure. *J Gen Intern Med* 16:606–613.
- Little TD (2013) *The Oxford handbook of quantitative methods in psychology: Vol. 2: statistical analysis (Vol. 2)*. Oxford University Press, New York, NY.
- Lo Y, Mendell NR, Rubin DB (2001) Testing the number of components in a normal mixture. *Biometrika* 88:767–778.
- Magura S (2008) Effectiveness of dual focus mutual aid for co-occurring substance use and mental health disorders: a review and synthesis of the "Double Trouble" in recovery evaluation. *Subst Use Misuse* 43:1904–1926.
- Mann K, Aubin HJ, Witkiewitz K (2017) Reduced Drinking in alcohol dependence treatment, what is the evidence? *Eur Addict Res* 23:219–230.
- McLellan AT, Cacciola JC, Alterman AI, Rikoon SH, Carise D (2006) The Addiction Severity Index at 25: origins, contributions and transitions. *Am J Addict* 15:113–124.
- Mueser KT, Yarnold PR, Rosenberg SD, Swett C, Miles KM, Hill D (2000) Substance use disorder in hospitalized severely mentally ill psychiatric patients: prevalence, correlates, and subgroups. *Schizophr Bull* 26:179–192.
- Muthén LK, Muthén BO (2018) *Mplus User's Guide*, 8th edn. Muthén Muthén, Los Angeles, CA. <https://doi.org/10.1111/j.1600-0447.2011.01711.x>
- Nagin D (2005) *Group-based modeling of development*. Harvard University Press, Cambridge, MA.
- Nagin DS, Odgers CL (2010) Group-Based Trajectory modeling in clinical research. *Annu Rev Clin Psychol* 6:109–138.
- Najt P, Fusar-Poli P, Brambilla P (2011) co-occurring mental and substance abuse disorders: a review on the potential predictors and clinical outcomes. *Psychiatry Res* 186:159–164.
- National Institute on Drug Abuse (2020) *Common Comorbidities with Substance Use Disorders, Part 1: The Connection Between Substance Use Disorders and Mental Illness*. National Institute on Drug Abuse, Bethesda, MD.
- Nylund-Gibson K, Masyn KE (2016) Covariates and mixture modeling: results of a simulation study exploring the impact of misspecified effects on class enumeration. *Struct Equ Model* 23:782–797.
- Olino TM, Klein DN, Lewinsohn PM, Rohde P, Seeley JR (2010) Latent trajectory classes of depressive and anxiety disorders from adolescence to adulthood: descriptions of classes and associations with risk factors. *Compr Psychiatry* 51:224–235.
- Overall JE, Reilly EL, Kelley JT, Hdlister LE (1985) Persistence of depression in detoxified alcoholics. *Alcohol Clin Exp Res* 9:331–333.
- Painter JM, Malte CA, Rubinsky AD, Campellone TR, Gilmore AK, Baer JS, Hawkins EJ (2018) High inpatient utilization among Veterans Health Administration patients with substance-use disorders and co-occurring mental health conditions. *Am J Drug Alcohol Abuse* 44:386–394.
- Sobell LC, Brown J, Leo GI, Sobell MB (1996) The reliability of the Alcohol Timeline Followback when administered by telephone and by computer. *Drug Alcohol Depend* 42:49–54.
- Stoffelmayr BE, Benishek LA, Humphreys K, Lee JA, Mavis BE (1989) Substance abuse prognosis with an additional psychiatric diagnosis: understanding the relationship. *J Psychoactive Drugs* 21:145–152.
- Substance Abuse and Mental Health Services Administration (2019) *Key substance use and mental health indicators in the United States: Results from the 2018 National Survey on Drug Use and Health*. HHS Publication No. PEP19-5068, NSDUH Series H-54 170:51–58. <https://doi.org/10.1016/j.drugalcdep.2016.10.042>

- Suter M, Strik W, Moggi F (2011) Depressive symptoms as a predictor of alcohol relapse after residential treatment programs for alcohol use disorder. *J Subst Abuse Treat* 41:225–232.
- Timko C, Cronkite RC, McKellar J, Zetmore S, Moos RH (2013) Dually diagnosed patients' benefits of mutual-help groups and the role of social anxiety. *J Subst Abuse Treat* 44:216–223.
- Timko C, Harris AHS, Jannausch M, Ilgen M (2019) Randomized controlled trial of telephone monitoring with psychiatry inpatients with co-occurring substance use and mental health disorders. *Drug Alcohol Depend* 194:230–237.
- Timko C, Ilgen M, Haverfield M, Shelley A, Breland JY (2017) Polysubstance use by psychiatry inpatients with co-occurring mental health and substance use disorders. *Drug Alcohol Depend* 180:319–322.
- Tonigan JS, Pearson MR, Magill M, Hagler KJ (2018) AA attendance and abstinence for dually diagnosed patients: a meta-analytic review. *Addiction* 113:1970–1981.
- Torrens M, Martínez-Sanvisens D, Martínez-Riera R, Bulbena A, Szerman N, Ruiz P (2011) Dual diagnosis: Focusing on depression and recommendations for treatment. *Addict Disord their Treat* 10:50–59.
- Trivedi AN, Matula S, Miake-Lye I, Glassman PA, Shekelle P, Asch S (2011) Systematic review: comparison of the quality of medical care in veterans affairs and non-veterans affairs settings. *Med Care* 49:76–88.
- Watkins KE, Paddock SM, Hudson TJ, Ounpraseuth S, Schrader AM, Hepner KA, Sullivan G (2016) Association Between Quality Measures and Mortality in Individuals With co-Occurring Mental Health and Substance Use Disorders. *J Subst Abuse Treat* 69:1–8.
- Wickrama K, Mancini JA, Kwag K, Kwon J (2013) Heterogeneity in multidimensional health trajectories of late old years and socioeconomic stratification: a latent trajectory class analysis. *J Gerontol Ser B Psychol Sci Soc Sci* 68:290–297.
- Witkiewitz K, Tucker JA (2020) Abstinence not required: expanding the definition of recovery from alcohol use disorder. *Alcohol Clin Exp Res* 44(1): 36–40.
- Worley MJ, Tate SR, Mcquaid JR, Granholm EL, Brown SA (2013) 12-Step affiliation and attendance following treatment for comorbid substance dependence and depression: A latent growth curve mediation model. *Subst Abuse* 34:43–50.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Fig. S1. Diagram illustrating the mean values and wide variance (heterogeneity) in scoring among each of the measures included in the parallel latent class trajectory analysis.