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Multimorbidity classes indicate differential patterns of health care engagement among people who inject drugs

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Abstract

Background: Aging people who inject drugs (PWID) have complex health needs. Health care management could be complicated by persistent substance use, multiple health challenges, and inconsistent access to care. However, we know little about the relationship between chronic multimorbidity and health care engagement in this population. The purpose of this study is to characterize patterns and correlates of chronic disease multimorbidity among PWID.

Methods: We conducted a latent class analysis (LCA) using data from the AIDS Linked to the IntraVenous Experience (ALIVE) Study, a community-based observational cohort, to determine classes of multimorbid chronic diseases. We then conducted regressions to determine factors associated with class membership and the impact of each multimorbid class on health events and utilization.

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Declaration of competing interest

The authors report no real or perceived vested interests related to this article that could be construed as a conflict of interest.

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Results: Of 1387 individuals included, the majority were male (67%) and Black (81%), with a mean age of 53 years. We identified four classes of multimorbidity: *Low Multimorbidity* (54%), *and Low Multimorbidity Including Psychiatric Comorbidity* (26%), *Multimorbidity* (12%), and *Multimorbidity Including Psychiatric Comorbidity* (7%). Female sex, baseline age, and receipt of disability were factors significantly associated with membership in all three classes compared to the *Low Multimorbidity* class. Additionally, PWID in these three classes were significantly more likely to utilize emergency room and outpatient health care. Membership in both classes with psychiatric comorbidity was associated with significantly higher adjusted odds of receiving medication for opioid use disorder.

Discussion: Holistic health care systems can best address the needs of aging PWID with integrated care that provides harm reduction, substance use and mental health treatment together, and wrap around services.

Keywords

Chronic disease; Opioid use; Healthcare utilization; Latent class analysis

1. Introduction

In the United States, aging people who inject drugs (PWID) have complex health needs. Treatment guidelines and health care services designed to provide care to PWID often limit the scope to infectious disease treatment and prevention, skin and soft tissue infections, and harm reduction strategies, with little attention paid to engagement in health care for treatment of chronic diseases that can be diagnosed and managed in primary care (Centers for Disease Control and Prevention, 2012; Low et al., 2016; Visconti et al., 2019). Increased primary care utilization generally leads to improved health outcomes for persons with substance use disorder and results in reduced cost to health systems (Chi et al., 2011; Park et al., 2015; Parthasarathy et al., 2012). However, PWID utilize primary care at low rates. Consequently, they may overutilize emergency and inpatient care, and accordingly are often seen in later stages of disease (Artenie et al., 2015; Larney et al., 2017; Mizuno et al., 2015; Okeke et al., 2015; Thompson et al., 2018; Westergaard et al., 2013). Therefore, we must understand the holistic health care needs of PWID to target services and optimize health care engagement.

According to the Behavioral Model for Vulnerable Populations, adapted from the Andersen Model of Healthcare Utilization, predisposing, enabling, need, and health behavior factors influence primary care utilization and engagement (Andersen, 1968; Gelberg et al., 2000). Predisposing factors are individual characteristics such as age, race, and sex; enabling characteristics include access, social, and structural barriers within the health care infrastructure; need characteristics refer to both evaluated and perceived health conditions; health behaviors for PWID are actions taken by individuals that relate to management of multimorbid diseases and substance use. The impact of predisposing, enabling, and health behavior characteristics on health care engagement for PWID has been well studied. Enabling characteristics such as insurance status, low clinician continuity, and stigma decrease primary care and outpatient service engagement (Hartzler et al., 2018; Westergaard et al., 2011, 2013). Predisposing characteristics of Black race, Hispanic ethnicity, and

younger age have all been linked with decreased utilization and engagement (Hoots et al., 2017; Lesko et al., 2019). Conversely, a research has demonstrated that a number of enabling factors facilitate health care access and engagement, such as medication for opioid use disorder (MOUD), integrated care services, and focused retention interventions (Islam et al., 2013; Mehta et al., 2015; Miller et al., 2018; Morozova et al., 2017). However, how primary care engagement may be further influenced by "need"-based characteristics from the Behavioral Model, particularly multimorbid chronic diseases, remains unclear.

Multimorbidity (having two or more co-occurring diseases) has been previously reported to be common and under-addressed for PWID (Johnston et al., 2019), with prior studies demonstrating prevalence as high as 58% for diabetes, obstructive lung disease, liver disease, kidney dysfunction, and hypertension among PWID (Cullen et al., 2009; Krupski et al., 2015; Monroe et al., 2011; Salter et al., 2011). Moreover, multimorbid diseases among PWID are widely undiagnosed or under-treated. As many PWID in the United States age, the prevalence of multimorbidity is likely to increase; thus understanding the impact of having multiple and sometimes undiagnosed chronic conditions will be important for optimizing care (Piggott et al., 2013, 2016; Salter et al., 2011).

The purpose of this study is to define the phenotypes of multimorbidity using latent class analysis (LCA) for a population of community based PWID and associations between multimorbid disease states and health care engagement, accounting for predisposing, enabling, and health behavior factors. Taken together, the findings of this study classify all domains of health care engagement from the Behavioral Model specific to PWID and highlight areas for targeted and holistic healthcare.

2. Methods

2.1. Study sample

The study derived data from the AIDS Linked to the Intravenous Experience (ALIVE), a community-based cohort study with current and former people who inject drugs in Baltimore, MD. The ALIVE Study was first established in 1988 to characterize the incidence and natural history of HIV among PWID (Vlahov et al., 1991). Subsequent recruitment waves of new participants occurred during 1994–1995, 1998, 2005–2008, and 2015–2018. Eligibility criteria for the ALIVE Study included being 18 years or older, negative for HIV or free of clinical AIDS, and reporting injection drug use in the 6 months prior to enrollment. Biannual study visits with participants included an interview, clinical examination, and biospecimen collection, which included HIV antibody tests for HIV negative participants, HIV RNA and CD4 cell count for participants living with HIV, complete blood count, comprehensive metabolic panel, and hemoglobin A1c. All participants provided written informed consent prior to participation in the study. The Johns Hopkins Bloomberg School of Public Health Institutional Review Board approved study procedures.

The sample for the current study included participants with data collected in 2015–2019 (N = 1646) who had at least two study visits by the end of 2019 (N = 1387). From January 2015 through the end of December 2019, participants included in the analysis had a median

of 8 visits (25th–75th percentile: 6–10). The first study visit for each participant in the study period represents their baseline visit for this analysis. Compared to those included in this analysis, those who were excluded because they did not have at least two study visits were significantly more likely to be male ($p = 0.03$), younger ($p < 0.001$), non-Black race ($p < 0.001$), report injection drug use in the last 6 months ($p < 0.001$), emergency room utilization in the last 6 months ($p < 0.001$), and less likely to be living with HIV ($p = 0.001$), but were otherwise similar on baseline disability status, outpatient health care utilization, insurance status, and baseline prevalence of all other diseases included as latent class indicators.

2.2. Measures

2.2.1. Latent class indicators—The study examined data on the presence or absence of chronic diseases commonly treated in the outpatient clinical setting salient to a population of PWID: Anxiety/Depression, Major psychiatric disease (Bipolar disorder and/or Schizophrenia), Diabetes, Hypertension, Arthritis, Obstructive airway disease, HIV, Liver fibrosis/Cirrhosis, and Renal dysfunction. Individuals were classified as having or not ever having each disease based on time-updated clinical, laboratory, and self-reported data collected during follow-up visits using the established criteria we describe in Table 1.

2.2.2. Covariates associated with class membership—The study team selected covariates based on characteristics described by the Behavioral Model for Vulnerable Population as related to health care utilization and engagement in three categories: predisposing, enabling and health behaviors, with definitions listed in Table 1.

2.2.3. Health events and health care utilization—Health events were dichotomous variables in two major groups: infectious or cardiovascular. This study classified individuals as having or not ever having each event from each study visit with criteria described in Table 1. We used health care utilization measures from participant's last visit with definitions described in Table 1.

2.3. Statistical analysis

The research team conducted latent class analysis (LCA) to identify profiles of multimorbidity in Mplus Version 8.1 (Muthen & Muthen, 2011). The Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), sample size adjusted Bayesian Information Criteria (aBIC), Lo-Mendell-Rubin adjusted likelihood ratio test (LMR-LRT), and Bootstrapped likelihood ratio test identified the optimal number of multimorbid disease classes (Nylund et al., 2007). The study also considered interpretability of the classes based on the conditional probabilities of disease indicators and entropy of class membership in selecting the final class distributions (Celeux & Soromenho, 1996).

Following the identification of the optimal number of classes, the study included predisposing, enabling, and health behavior characteristics as covariates with unadjusted regressions using the R3STEP function in MPlus. This function examines that covariate's correlation with a multimorbidity class, relative to a reference class. The reference for all models was the class with the lowest percent of multimorbid diseases. Guided by

the Behavioral Model, the study selected a priori variables of age, sex, race, insurance, and drug use (defined in Table 1) for the final adjusted model regardless of statistical significance (Gelberg et al., 2000). We selected other enabling and health behavior variables with statistically significant ($p < 0.05$) unadjusted associations with any class for the final adjusted model. The team applied controls for number of study visits and number of days between first and last visit in the adjusted model.

Finally, we examined the association of multimorbid class on dichotomous outcomes of health care utilization and health events using logistic regressions, controlling for predisposing, enabling, and health behavior characteristics using Stata (StataCorp, 2013).

3. Results

3.1. Demographic characteristics

Of the 1387 individuals included, the majority were male (67%) and Black (81%). At baseline, the mean age was 53 years old (25th–75th percentile: 24–74). Less than one-third reported an annual income greater than $5000 (31%), and most reported receiving disability in the prior 6 months (80%). Three percent of the study sample reported being uninsured in the last 6 months at baseline, with 85% reporting coverage with Medicare or Medicaid. At the first visit in this analysis, 56% of this study population reported substance use in the previous 6 months, with 14% reporting noninjection use only, 37% reporting both injection and noninjection use, and 5% reporting injection drug use exclusively (5%). Finally, at baseline, almost a third of the participants reported using emergency room services in the previous 6 months and three quarters utilizing outpatient health care services (Table 2).

3.2. Model selection

A comparison of model fit indices indicated that a four-class solution was preferred (Supplemental Table 1). HIV was the only disease indicator that the team dropped from analysis, as its conditional probabilities were similar in each class; model fit and interpretability improved with its exclusion. Additionally, the study identified HIV and viral load status as covariates of class membership, but neither was associated with class membership. Information criteria showed a split between a 3 and 4 class solution, with the BIC lower for the former and AIC lower for the latter. Additionally, the bootstrapped LMR/LTR indicated a four-class solution significantly improved fit compared to three classes (Nylund et al., 2007). A four-class solution and its interpretability highlighted the following patterns of multimorbidity: *Low multimorbidity* (54%), *Low multimorbidity including psychiatric comorbidity* (26%), *Multimorbidity* (12%), and *Multimorbidity including psychiatric comorbidity* (7%).

3.3. Multimorbidity classes

Table 3 lists the conditional probabilities of each disease in the four multimorbid classes, the probability of being diagnosed with each disease given inclusion in that class, converted to percentages. The four classes had similar conditional percentages of obstructive airway disease (24–38%) and hypertension (96–100%). Within classes, *Low multimorbidity* and *Low multimorbidity including psychiatric comorbidity* had similar lower

conditional percentages of diabetes, liver fibrosis, renal dysfunction, and arthritis compared to the *Multimorbidity* and *Multimorbidity including psychiatric comorbidity* classes, which had high conditional percentage of these nonpsychiatric diseases. Between classes, psychiatric comorbidity distinguished these classes, with high conditional percentage of Anxiety/Depression and Major Psychiatric Disorders in the *Low multimorbidity including psychiatric comorbidity* and *Multimorbidity including psychiatric comorbidity* classes compared to their counterparts.

3.4. Baseline correlates of class membership

Table 4 shows the correlates of class membership relative to class 1, *Low multimorbidity*. From the predisposing domain, sex and age were significant covariates. Female sex was significantly associated with membership in all three classes, with highest adjusted odds of membership in the *Multimorbidity including psychiatric comorbidity* class (aOR 4.2; 95% CI 2.7–6.6). Participants older than 55 years of age had 70% lower adjusted odds (aOR 0.3; 95% CI 0.2–0.5) of being in the *Low multimorbidity including psychiatric comorbidity* class than the *Low multimorbidity* class. Baseline disability, income, and insurance, all enabling characteristics, were associated with class membership. Baseline disability was associated with all three classes but remained statistically significant only for the two psychiatric comorbidity classes in the adjusted model, and strongest for the *Multimorbidity including psychiatric comorbidity* class (aOR 2.2; 95% CI 1.4–3.6). Participants reporting an annual income less than $5000 at baseline had 60% lower adjusted odds of membership in the *Multimorbidity* class (aOR 0.4; 95% CI 0.3–0.8). Baseline insurance was associated with nearly 4 times higher adjusted odds of membership in the *Low multimorbidity including psychiatric comorbidity* class (aOR 3.8; 95% CI 1.1–13.3). Health behaviors of substance use and its association with class membership varied. Reporting baseline noninjection and injection- and noninjection drug use was significantly associated with over two-fold higher adjusted odds of membership in the *Low multimorbidity including psychiatric comorbidity* class. Additionally, reporting injection- and noninjection drug use was significantly associated with 60% lower odds of membership in the *Multimorbidity* class in adjusted analysis (aOR 0.4; 95% CI 0.2–0.9). Baseline alcohol use was associated with 50% lower adjusted odds of membership in the *Multimorbidity with psychiatric comorbidity* class (aOR 0.5; 95% CI 0.3–0.8) while baseline cigarette use was associated with 50% lower odds of membership in the *Multimorbidity* class in adjusted analysis (aOR 0.5; 95% CI 0.2–0.9).

3.5. Differences in health care utilization and health events

Table 5 displays odds ratios of associations between class membership and health care utilization and health event outcomes, using the *Low multimorbidity* class as the reference and controlling for baseline age, sex, race, income, disability, care continuity, substance use, number of study visit, and number of days between first and last visit in the adjusted logistic regression model. Compared to those in the *Low multimorbidity* class, persons in the *Multimorbidity* and *Multimorbidity including psychiatric comorbidity* classes had significantly higher odds of an infectious disease health event, but only the later class remained statistically significant in the adjusted model (aOR 2.1; 95% CI 1.4–3.3). Both *Multimorbidity* (OR 2.0; 95% CI 1.2–3.5) and *Multimorbidity including psychiatric*

comorbidity (OR 2.1; 95% CI 1.1–4.1) had significantly higher odds of a cardiovascular health event, but neither were statistically significant in the adjusted model. Both of these classes had approximately 2 times significantly higher adjusted odds of inpatient hospitalization in the last 6 months compared to the *Low multimorbidity* group. All three classes had significantly higher odds of emergency room and outpatient health care visits in the last 6 months compared to the *Low multimorbidity* class, with the *Multimorbidity* having the highest adjusted odds of outpatient (aOR 2.0; 95% CI 1.2–3.3) and emergency room (aOR 2.0; 95% CI 1.3–2.8) utilization. Finally, both classes with psychiatric comorbidity had significantly higher odds of MOUD prescription in the last 6 months, with the *Multimorbidity including psychiatric comorbidity* having 2 times higher adjusted odds and the *Low multimorbidity including psychiatric comorbidity* having 1.4 times higher adjusted odds compared to the *Low multimorbidity* class.

4. Discussion

This study provides new evidence regarding health care engagement for PWID. Using the Behavioral Model for Vulnerable populations, we identified the need characteristics with unique classes of multimorbidity; the predisposing, enabling, and health behavior characteristics associated with each class; and impact of these need-based multimorbidity classes on health care engagement. From predisposing characteristics, we observed higher levels of multimorbidity among women and from the enabling characteristics, those receiving disability were significantly associated with a psychiatric comorbidity class. Moreover, the data suggest that high levels of multimorbidity are associated with greater health care utilization and adverse health events, including some driven by psychiatric comorbidity. Our findings reinforce the complex nature of health care engagement for PWID, and through the lens of the need characteristics, identify avenues for clinical interventions based on multimorbidity class, especially given the high burden of psychiatric comorbidity observed.

Multiple studies have examined classes of multimorbidity in the general aging population using latent class analysis (Barile et al., 2015; Cigolle et al., 2011; Gonsoulin et al., 2017; Hall et al., 2018; Islam et al., 2014; Juul-Larsen et al., 2020; Khorrami et al., 2020; Kuwornu et al., 2014; Larsen et al., 2017; Olaya et al., 2017; Park et al., 2019; Sibley et al., 2014; Whitson et al., 2016). While those studies differ in their selection and measurement of diseases, their findings, like ours, demonstrated heterogeneity in multimorbidity classes. One study in particular (Barile et al., 2015) found a similar four class structure, but with more cardiometabolic, gastrointestinal, and musculoskeletal diagnoses considered. A systematic review of multimorbidity profiles using different clustering approaches found in its synthesis of latent class analysis studies two interpretable clusters, one of mental health disorders and another of asthma and COPD; the review also saw an additional discernable axis of cardiometabolic diseases (Busija et al., 2019). Our findings reinforce heterogeneity in multimorbidity clustering, particularly as it relates to clustering around mental health disorders. Our findings expand on this work by examining multimorbidity in an understudied population of PWID, and by examining the relationship between multimorbidity and health care engagement and utilization.

We found a high burden of psychiatric comorbidity, with two named classes based on this finding. While measured inconsistently across studies, seven studies had a distinct class with a psychiatric comorbidity (Barile et al., 2015; Islam et al., 2014; Juul-Larsen et al., 2020; Kuwornu et al., 2014; Larsen et al., 2017; Olaya et al., 2017; Park et al., 2019). Five of these studies found depression and/or anxiety in a distinct class, or comorbid with noncardiometabolic disease (e.g., allergies, headache, asthma) similar to the *Low multimorbidity including psychiatric comorbidity* class (Islam et al., 2014; Juul-Larsen et al., 2020; Kuwornu et al., 2014; Larsen et al., 2017; Park et al., 2019). Olaya et al. (2017) identified a class similar to the *Multimorbidity including psychiatric comorbidity* class with high conditional percentage of depression with cardiorespiratory and arthritis multimorbidity. Only one study (Barile et al., 2015) found two classes with psychiatric comorbidity, both of which were similar to the psychiatric comorbidity classes in this study. Both *Low multimorbidity including psychiatric comorbidity* and *Multimorbidity including psychiatric comorbidity* classes also included high conditional prevalence of major psychic disorder (bipolar disorder and/or schizophrenia), which were not included as indicators in any other studies. These two classes also had much higher conditional prevalence of anxiety/depression compared to similar classes in other studies. Conditional percentage for anxiety/depression indicators in other studies ranged from 17 to 70% (Islam et al., 2014; Juul-Larsen et al., 2020; Kuwornu et al., 2014; Larsen et al., 2017; Park et al., 2019), which was similar to the conditional percentages seen in the *Low multimorbidity* and *Multimorbidity* classes, indicating a high burden of psychiatric comorbidity for PWID. Additionally, this identification of distinct classes of psychiatric comorbidity had implications for health care utilization, as well as for areas for clinicians to target when engaging this population in outpatient care.

While all three classes had significantly higher odds of health care utilization compared to the *Low multimorbidity* class, both psychiatric comorbidity classes also had high significant adjusted odds of receipt of MOUD. Other studies with PWID have demonstrated co-location of MOUD with primary and outpatient care as a factor correlated with engagement (Islam et al., 2013; McNeil et al., 2014; Mehta et al., 2015; Morozova et al., 2017). Recent evidence from the ALIVE Study also demonstrated greater use of MOUD among those seeking treatment for mental health conditions (Genberg et al., 2019). Finally, these psychiatric comorbidity classes also had high odds of emergency room utilization, and the *Multimorbidity including psychiatric comorbidity* class had high significant adjusted odds of an inpatient hospitalization in the last 6 months compared to the *Low multimorbidity* class. While some of these utilization measures were also true of the *Multimorbidity* class, the psychiatric diagnoses may play a salient role as one study determined severity of mental health disorders significantly associated with increased utilization of emergency room services (Niedzwiecki et al., 2018) with another systematic review showing that attempted suicide or self-harm were potential drivers of this utilization (Barratt et al., 2016). Research should prioritize closer follow-up of individuals in this class with integrated mental health and other outpatient health care services, including wrap-around case management.

The *Low multimorbidity* class was the largest of the four described here. Multiple studies have demonstrated a class with low conditional percentage of diseases compared to the other classes (Islam et al., 2014; Larsen et al., 2017; Olaya et al., 2017; Park et al., 2019;

Whitson et al., 2016). However, our *Low multimorbidity* class also had a high conditional percentage of hypertension (96%) compared to similar Low multimorbidity classes in these studies. Three studies (Kuwornu et al., 2014; Larsen et al., 2017; Sibley et al., 2014) found an additional class characterized by a high conditional percentage of hypertension alone, indicating a higher burden of hypertension for PWID, highlighting an unmet need that could be addressed with greater primary care engagement. The *Multimorbidity* class was characterized by high probabilities of all nonpsychiatric diseases. Though studies with geriatric populations had similar classes with high conditional percentage of all diseases studied (Hall et al., 2018; Juul-Larsen et al., 2020; Whitson et al., 2016), others had classes that were characterized by high conditional percentage of cardio-metabolic disease (i.e. hypertension, diabetes, hyperlipidemia, vascular disease, etc.) in a similar manner to our *Multimorbidity* class (Gonsoulin et al., 2017; Islam et al., 2014; Khorrami et al., 2020; Kuwornu et al., 2014; Larsen et al., 2017; Olaya et al., 2017; Park et al., 2019; Sibley et al., 2014). Future work with this population should consider additional comorbidities, particularly cardio-metabolic diseases, to determine if identifiable classes existed based on disease system for targeted clinical interventions.

Our findings also highlighted other Behavioral Model characteristics that impact health care engagement. Receipt of disability was an important enabling characteristic significantly associated with both classes with psychiatric comorbidity. This association has been well documented. One study found that individuals with mental health disorders represented a large component of disability services, and that more than 50% of individuals require multiple applications to Supplemental Security Income (SSI) and Social Security Disability Insurance (SSDI) to access these essential social services (Goldman et al., 2018). Some programs have assisted those who have mental health and other co-occurring disorders with these applications (Dennis et al., 2011). These outreach services can be initial touchpoints and can also perform linkage to essential health care services and other enabling factors like health insurance. From health behaviors, individuals reporting injection and noninjection drug use at the baseline visit in our study were significantly less likely to be in the *Multimorbidity* class. Previous studies within the ALIVE cohort also demonstrated the decreased odds of injection drug use with increased multimorbidity (Salter et al., 2011). Additionally, the decreased odds of injecting for this group could be related to the increased utilization of outpatient care or may reflect the impact of comorbid disease, though prior studies have only found associations with active injection drug use and lower health care utilization (Maragh-Bass et al., 2017). From the predisposing domain, while female sex was associated with membership in all three classes, both classes with psychiatric comorbidity had higher effect estimates of this association, with female sex having over 4 times higher adjusted odds of membership in *Multimorbidity including psychiatric morbidity* class compared to the *Low Multimorbidity* class. This relationship between sex and diagnosis of a psychiatric condition is consistent with national reporting of women having higher prevalence of any mental illness, depression/anxiety, and severe mental illness (Bose et al., 2018). This finding warrants further study to assess additional barriers to health care engagement, while accounting for multimorbid disease management. This study did not collect and could not assess experiences unique to women and gender non-conforming

people, including gender-based violence; such data would inform future clinical assessments and primary care priorities (Muncan et al., 2020; Shirley-Beavan et al., 2020).

4.1. Limitations

This study has limitations. While the study measured diseases over a five-year period and most with a physiological or biological marker to confirm diagnosis, some disease states were classified by self-report alone. This is a particular limitation with severe psychiatric disorders, though the study based classification on self-report of diagnosis or prescription of a medication. An overlap also existed with measurement of diseases over the five-year period and the health care utilization and health event data, limiting the temporality of associations. However, this study's purpose was to determine the holistic needs of an aging population of PWID and not infer causality of multimorbidity class on outcomes. Our study's restriction to participants with two study visits between 2015 and 2019 limited the sample size, though sensitivity analysis with all participants during the time period showed a similar 4 class structure of multimorbidity. Additionally, participants excluded from this study due to not having a second study visit between 2015 and 2019 were significantly more likely to report injection drug use at baseline in the sensitivity analysis ($p < 0.001$), a potential factor related to being lost to follow up. Because these data came from an aging population of largely Black, male, urban dwellers, its findings may not be generalizable to the larger population of people who inject drugs. Future studies should attempt to classify based on severity of disease states and utilize longitudinal data to determine transitions of multimorbid disease management. Finally, we dropped HIV as an indicator given its conditional probability being similar in all four classes. This finding suggests potential effect measure modification and that future work should determine the burden of multimorbidity stratified by HIV status.

5. Conclusions

As current or former PWID seek health care, their needs extend beyond the traditional realms of substance use. This study demonstrates heterogeneity in multimorbidity for PWID with distinct latent classes. Three of these classes of multimorbidity indicate greater health care need and the need for interventions to improve engagement. Additionally, two classes had enhanced need for care because of co-occurring mental health disorders. Clinicians can capitalize on the implications for each class, tailoring follow-up and care services to best address the needs of multimorbidity classes. Holistic health care systems can address these needs best with integrated care systems that provide harm reduction, substance use and mental health treatment together, and wrap around social services, particularly as this population continues to age.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Definitions for chronic disease indicators, covariates associated with class membership, and health events and healthcare utilization.

Disease	Definition
Arthritis	Self-report arthritis diagnosis or treatment in the last 6 months
Anxiety/depression	Self-report anxiety or depression diagnosis/ treatment in the last 6 months, or Centers for Epidemiologic Studies Depression Scale (CES-D) scores of 23+ (Carleton et al., 2013).
Diabetes	Self-reported diabetes medication taken in past 6 months, or Hemoglobin A1c (HbA1c) concentration of >6.5
Hypertension	Self-reported hypertension medication in the last 6 months, or 2+ study visits with blood pressure readings of systolic ≥140 or diastolic ≥90
HIV	Self-reported antiretroviral therapy (ART) in the last 6 months or confirmed HIV antibody test.
Liver fibrosis	Transient elastography (FibroScan) measurements of median liver stiffness, classified by cutoffs for F2 fibrosis (kPa ≥ 9.3) (Kirk et al., 2009)
Major psychiatric disorders	Self-reported medications for/diagnosis of bipolar disorder, schizophrenia, or schizoaffective disorder.
Obstructive airway	Forced expiratory volume in 1 s to forced vital capacity of ≤70%
Renal dysfunction	Estimated glomerular filtration rate < 60 mL/min/1.73m^2 using MDRD equation.
Covariate	**Definition (at first study visit)**
Age	Measured as a continuous variable at the first study visit and transformed into a dichotomous variable near the median age of 55 years old.
Sex	Dichotomous variable comparing self-report male vs. female sex.
Race	Classified as Black compared to non-Black race.
Income	A dichotomous variable comparing individuals with an income less than $5000 dollars per year to income greater than $5000 per year
Disability	Measured as a dichotomous variable based on the following question: “Currently, are you receiving SSI (Supplemental Security Income) or SSDI (Social Security Disability Income), or any other type of disability?”
Insurance	Self-report health insurance in the last six months
Continuity of care	Self-report of healthcare visits with the same healthcare provider for the last 2 years at the first visit
Drug use	Self-report of heroin, cocaine, crack, and/or speedball use and route in the last 6 months classified the following categories: Injection only, non-injection only, both injection and non-injection and no substance use (ref)
Alcohol use	Self-report of any alcohol use in the last 6 months.
Cigarette use	Binary variable for self-report of any cigarette use in the last 6 months.
Health events	**Definition**
Infectious	Self-report of diagnosis or treatment for sepsis, pneumonia, endocarditis or skin infection in the last 6 months at a study visit between 2015 and 2019
Cardiovascular	Self-report of diagnosis or treatment for myocardial infarction, heart failure, heart disease, or stroke in the last 6 months at a study visit between 2015 and 2019
Healthcare utilization	**Definition (at last study visit)**

Emergency room	Self-report utilization of emergency room services in the last six months
Outpatient visit	Self-report utilization of outpatient healthcare services in the last 6 months
Medication for opioid use	disorder Self-report prescription of buprenorphine, naltrexone, or methadone in the last 6 months

Table 2

Study sample baseline[a] characteristics, 1387 ALIVE participants with a study visit in 2015 and 2019.

		Total n = 1387	
		n	%
Predisposing	Age, median (range)	53	(27–77)
	Female sex	459	33
	Black race	1119	81
Enabling	Annual income <$5000	959	69
	Disability	1105	80
	Insurance last 6 months	1349	97
	Same provider in the last 2 years	775	56
Health behaviors (last 6 months)	Non-injection drug use only	193	14
	Injection drug use only	70	5
	Both injection and non-injection drug use	512	37
Healthcare utilization (last 6 months)	Emergency Department Visit	439	32
	Outpatient Clinic Visit	1046	75
	Medication for Opioid Use Disorder[b]	734	53
Need characteristics	HIV	413	30
	Diabetes	124	9
	Hypertension	826	60
	Renal Disease	110	8
	Arthritis	465	34
	Major Psychiatric Comorbidity[c]	393	28
	Anxiety/Depression	629	45
	Fibrosis (≥ 9.3 kPa)[d]	182	24
	Obstructive Airway Disease[e]	152	23

[a] First study visit in 2015–2019 represents the baseline visit.

[b] Methadone, Buprenorphine, or Naltrexone.

[c] Bipolar or Schizophrenia.

[d] Fibroscan available for only 753 participants at first visit.

[e] FEV/FCV available for only 658 participants at first visit.

Table 3

Latent classes of multimorbidity classified by individual disease indicators, n = 1387 ALIVE participants from 2015 to 2019.

	Class 1	**Class 2**	**Class 3**	**Class 4**
	n = 745 (54%)	**n = 368 (26%)**	**n = 172 (12%)**	**n = 102 (7%)**
	Low multimorbidity	**Low multimorbidity including psychiatric comorbidity**	**Multimorbidity**	**Multimorbidity including psychiatric comorbidity**
Arthritis	21%	31%	**49%**	**48%**
Major psychiatric disorders (bipolar & schizophrenia)	2%	**100%**	0%	**100%**
Anxiety/depression	58%	**100%**	61%	**100%**
Diabetes	7%	0%	**75%**	**100%**
Liver fibrosis	12%	14%	**38%**	**28%**
Hypertension	96%	97%	98%	100%
Obstructive airway	38%	34%	24%	29%
Renal dysfunction	16%	17%	**29%**	**32%**

Bolded are conditional prevalences that are noteworthy for that class.

Table 4

Estimates of class membership with baseline characteristics (relative to low multimorbidity class), n = 1387 ALIVE participants from 2015 to 2019.

Class	Low multimorbidity with psychiatric comorbidity		Multimorbidity		Multimorbidity including psychiatric comorbidity	
Covariate	**OR (95% CI)**	**aOR[a] (95% CI)**	**OR (95% CI)**	**aOR[a] (95% CI)**	**OR (95% CI)**	**aOR[a] (95% CI)**
Predisposing characteristics						
Age > 55 years	**0.5 (0.3–0.7)**	**0.3 (0.2–0.5)**	**2.3 (1.3–4.1)**	1.1 (0.6–2.1)	0.9 (0.6–1.4)	0.8 (0.5–1.3)
Female	**6.2 (3.8–10.7)**	**2.6 (1.9–3.5)**	**2.1 (1.1–4.1)**	**2.7 (1.5–4.7)**	**2.5 (1.6–3.7)**	**4.2 (2.7–6.6)**
Black race	0.7 (0.5–1.0)	0.8 (0.5–1.1)	20.5 (0.5–851.5)	4.0 (0.9–16.5)	1.9 (0.9–3.5)	1.5 (0.7–3.1)
Baseline enabling variables						
Income <$5000/year	0.9 (0.7–1.3)	0.8 (0.6–1.2)	**0.4 (0.2–0.6)**	**0.4 (0.3–0.8)**	0.9 (0.5–1.4)	0.9 (0.5–1.5)
Disability	**1.6 (1.2–2.1)**	**1.9 (1.4–2.6)**	**1.8 (1.1–2.9)**	1.4 (0.8–2.6)	**2.4 (1.5–3.8)**	**2.2 (1.4–3.6)**
Insurance	**4.5 (1.2–17.0)**	**3.8 (1.1–13.3)**	0.7 (0.2–2.5)	0.5 (0.1–2.1)	3.5 (0.4–27.1)	3.2 (0.5–23.0)
Continuity of care	1.3 (0.9–1.7)	1.3 (0.9–1.7)	**1.9 (1.1–3.1)**	1.0 (0.5–1.8)	**1.6 (1.0–2.6)**	1.1 (0.6–1.7)
Baseline health behaviors: substance use in the last 6 months						
Injection only	0.7 (0.4–1.4)	1.6 (0.8–3.1)	0.7 (0.2–2.2)	0.7 (0.2–2.5)	0.2 (0.02–1.2)	0.2 (0.03–2.0)
Non-injection only	**1.7 (1.2–2.4)**	**2.5 (1.6–3.9)**	0.5 (0.2–1.3)	0.4 (0.2–1.2)	1.4 (0.8–2.5)	1.5 (0.8–3.0)
Injection and non-injection	**1.6 (1.2–2.1)**	**2.3 (1.6–3.3)**	**0.2 (0.1–0.5)**	**0.4 (0.2–0.9)**	0.9 (0.6–1.4)	1.6 (0.9–2.9)
Alcohol use	1.1 (0.8–1.4)	0.9 (0.6–1.2)	0.6 (0.3–0.9)	0.9 (0.5–1.7)	**0.5 (0.4–0.8)**	**0.5 (0.3–0.8)**
Cigarette use	1.4 (0.9–2.1)	1.1 (0.7–1.7)	**0.3 (0.2–0.5)**	**0.5 (0.2–0.9)**	1.0 (0.5–1.7)	1.0 (0.5–1.9)

Boldface indicates statistical significance ($p<0.05$).

[a]Controlling for number of visits and number of days between first and last visit.

Table 5

Association between class membership on healthcare utilization and health events relative to *Low Multimorbidity* class, n = 1384 ALIVE participants from 2015 to 2019.

	Healthcare utilization								**Health events**			
	Medication for opioid use disorder[a]		**Outpatient visit**		**Emergency room visit**		**Inpatient stay**		**Cardiovascular[b]**		**Infectious[c]**	
	OR (95% CI)	**aOR[d] (95% CI)**	**OR (95% CI)**	**aOR[d] (95% CI)**	**OR (95% CI)**	**aOR[d] (95% CI)**	**OR (95% CI)**	**aOR[d] (95% CI)**	**OR (95% CI)**	**aOR[d] (95% CI)**	**OR (95% CI)**	**aOR[d] (95% CI)**
Low multimorbidity Psychiatric comorbidity	**1.9 (1.5–2.4)**	**1.4 (1.1–1.9)**	**1.4 (1.1–1.9)**	**1.6 (1.2–2.2)**	**1.6 (1.2–2.1)**	**1.5 (1.1–2.1)**	1.4 (0.9–1.9)	1.3 (0.9–1.9)	0.8 (0.4–1.4)	0.9 (0.5–1.7)	**1.6 (1.2–2.0)**	1.3 (0.9–1.7)
Multimorbidity	0.7 (0.5–1.1)	1.0 (0.7–1.4)	**2.6 (1.6–4.3)**	**2.0 (1.2–3.3)**	**1.8 (1.3–2.6)**	**2.0 (1.3–2.8)**	**1.8 (1.2–2.8)**	**1.9 (1.2–2.9)**	**2.0 (1.2–3.5)**	1.7 (0.9–2.9)	1.1 (0.7–1.5)	1.2 (0.8–1.7)
Multimorbidity Psychiatric comorbidity	**2.1 (1.3–3.3)**	**2.1 (1.3–3.5)**	**2.2 (1.2–3.9)**	**1.8 (1.0–3.4)**	**1.8 (1.3–2.7)**	**1.7 (1.1–2.8)**	**2.3 (1.4–3.8)**	**2.2 (1.3–3.7)**	**2.1 (1.1–4.1)**	1.9 (0.9–3.8)	**2.5 (1.6–3.8)**	**2.1 (1.4–3.3)**

[a]Medication for Opioid Use Disorder (MOUD) includes prescription of buprenorphine, naltrexone, or methadone in the last 6 months of the participant's last visit.

[b]Cardiovascular events include self-report myocardial infraction, heart failure, heart disease, or stroke between 2015 and 2019.

[c]Infectious events include self-report sepsis, pneumonia, endocarditis, or skin infection between 2015 and 2019.

[d]Controlling for baseline age, sex, race, income, disability, insurance, same provider>90% of visits, substance use, number of visits, and number of days between first and last visit.

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