Expanding Coverage and Addressing Social Determinants of Health in Pennsylvania Medicaid

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Abstract

Medicaid is the state-federal health insurance program for low-income Americans. A recent expansion of the program made Medicaid available to 800,000 additional enrollees in the Commonwealth of Pennsylvania. This expansion of coverage means that more Pennsylvanians than ever before will have access to medical care. The expansion, while necessary, is not sufficient to ensure that low-income Pennsylvanians get the care they need. Social determinants – conditions under which people live, shaped by the distribution of resources – also impact access to care, and can contribute to racial disparities. After examining the Medicaid expansion in Pennsylvania, this dissertation explores the public health impact of several social determinants impacting Pennsylvania Medicaid enrollees.

Chapter one is an assessment of the health care use of the Pennsylvania Medicaid expansion enrollment population, using group-based multi-trajectory modeling to jointly estimate six trajectories of ambulatory care and emergency department (ED) utilization in the first 12 months of enrollment. The heterogeneity we uncover may partially explain divergent research findings regarding how Medicaid expansion impacted use of the ED. Expansion states now have several years of experience with their Medicaid expansion populations and may be able to adopt our approach to identify subgroups who may benefit from interventions to improve access to ambulatory care and decrease ED use.

Chapter two assesses changes in Medicaid expenditures and utilization associated with receiving Permanent Supportive Housing (PSH), which integrates non-time-limited housing with supportive services for people who are disabled and chronically homeless. Additional state expenditures to expand financing for PSH services may be partially offset by reductions in Medicaid spending when Medicaid enrollees are stably housed, and may shift treatment to outpatient as opposed to acute care settings.

Black and Hispanic patients are significantly less likely than white patients to initiate and continue MOUD. In **chapter three**, we use data from the Allegheny County Department of Human Services Data Warehouse, which links administrative data from publicly administered health, human services and criminal justice systems, to explore whether this disparity is explained by contact with health and human services and criminal justice systems. We explain between 10% and 20% of the variation by race.

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This dissertation is dedicated:

To Medicaid enrollees in Pennsylvania. One in five Americans are enrolled in a Medicaid program at any given time. This dissertation is written about and for them.

To Beth, who has been my best friend since the very beginning.

To my Mom and Dad, whose belief in my abilities never wavered, even when I didn't quite believe in myself.

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1.0 Emergency Department and Ambulatory Care Visits in the First 12 Months of Coverage Under Medicaid Expansion: A Group-Based Trajectory Analysis

1.1 Abstract

Objective: More than 17 million people have gained health insurance coverage through the Affordable Care Act's (ACA) Medicaid expansion. Evidence on Medicaid expansion's impact on emergency department (ED) utilization has been mixed with some studies showing increases in ED use and others showing no changes. These conflicting findings may be partly explained by the heterogeneity of the Medicaid expansion population.

Method: We used group-based multi-trajectory modeling to jointly estimate trajectories of ambulatory care and ED utilization in the first 12 months of enrollment among Pennsylvania Medicaid expansion enrollees from 2015-2017.

Results: Among 601,877 expansion enrollees, we identified six distinct groups based on joint trajectories of ED and ambulatory care use. ED use varied across groups from 3.4 to 48.7 visits per 100 enrollees in the first month and between 2.8 and 44.0 visits per 100 enrollees in month 12. Ambulatory visits rates varied from 0.0 to 179 visits per 100 enrollees in the first month and from 0.0 to 274 visits in month 12. Rates of potentially preventable ED visits range from 3.64 to 52.68 per 100 people. Groups primarily varied on chronic condition diagnoses, including mental health and substance use disorders.

Conclusions: We find substantial variation in rates of ED and ambulatory care use across empirically defined subgroups of Medicaid expansion enrollees. This data-driven approach may

be used to target resources to encourage efficient use of ED services and support engagement with ambulatory care providers.

1.2 Introduction

The Patient Protection and Affordable Care Act (ACA) permits states to expand eligibility for Medicaid, the state-federal health insurance program for low-income Americans, to all adults under 138% of the federal poverty level. Over 17 million people have enrolled in the 37 states that have expanded Medicaid under the ACA.[1,2] There has been great interest in evaluating the impact of the ACA Medicaid expansion on changes in emergency department (ED) visits for several reasons. Frequent ED use may be a proxy for poor management of chronic conditions in an ambulatory care setting. Many argued the ACA would decrease ED use and increase use of outpatient services, particularly for conditions that are ambulatory care sensitive. ED care is typically more expensive than ambulatory care, and it does not provide recipients with preventive services or adequate management for chronic conditions.[3] The impact of the Medicaid expansion on ED use may differ from that of other health services because the Emergency Medical Treatment & Labor Act (EMTALA), enacted in 1986, already required EDs to provide enough care to stabilize patients when experiencing an emergency medical condition (although any patient may still be charged for that care).[4]

Research on ED use among Medicaid expansion enrollees has been mixed. At least one survey of low-income adults in three states (two that expanded, one that did not) found declining rates of ED use among expansion enrollees, but also found that these reductions may not be sustained in primary care shortage areas, implying a substitution effect.[5] Other observational

studies, including those focusing on individual states (Maryland, California) and multi-state studies (19 states that expanded in 2014) have reported increases in the proportion of ED visits financed by Medicaid but no overall change in the total number of ED visits following expansion.[6-10] Experimental evidence on changes in ED use after public insurance expansion is limited to the Oregon Health Insurance Experiment which found increases in ED use per person upwards of 40%.[11]

Few studies have examined how the heterogeneity of the Medicaid expansion population contributes to changes in ED and ambulatory care utilization. Despite being enrolled in the same broad eligibility category, Medicaid expansion enrollees differ substantially in the duration of previous coverage, their usual source of care, and health status, all of which may impact utilization. Sommers and Simon hypothesize that the effects of Medicaid expansion on ED use may depend on the characteristics of the population, network adequacy, and the geographic area of expansion.[12] In this paper, we used 2015-2017 Medicaid administrative data from Pennsylvania to jointly characterize longitudinal patterns in ambulatory care and ED utilization among Medicaid expansion enrollees to identify unique sub-groups in the population. Pennsylvania, which ranked fifth in Medicaid enrollment and prior to expansion, had no Medicaid eligibility for childless adults and limited eligibility (up to 38% of FPL) for parents and caretakers, is an ideal setting for this study.[13] Over 800,000 Pennsylvanians are enrolled in Medicaid through the expansion.[2]

We make two novel contributions: first, we examine heterogeneity in the population based on temporal variation in both ED and ambulatory care use, rather than predetermined characteristics. Second, we look at the diagnoses that brought individuals to the ED and their ambulatory care providers, which has been uncommon in Medicaid expansion research. Our findings will assist policymakers in understanding sources of heterogeneity in their Medicaid

expansion populations and in directing resources to encourage appropriate ED and ambulatory care use.

1.3 Methods

1.3.1 Data

We used Pennsylvania Medicaid fee-for-service and managed care organization claims from the Pennsylvania Department of Human Services from January 1, 2015, when Pennsylvania expanded Medicaid, to December 31, 2017. Demographic data on enrollees, including age, gender, race/ethnicity, county, and type of Medicaid eligibility were obtained from annual enrollment files. Outpatient facility, dental, and professional claims and encounter data were used to count visits to EDs and ambulatory care providers and determine the diagnoses coded for these visits. SAS 9.4 and Stata 15.1 were used for all data management and statistical analyses.[14,15]

1.3.2 Study Cohort

Our sample included Pennsylvania Medicaid expansion enrollees ages 19-64 years who were not dually-enrolled in Medicare at any point during the study period. The analysis is limited to those enrollees with at least 6 months of continuous expansion enrollment (gaps <=15 days were permitted) followed by 6 continuous months of Medicaid enrollment in any eligibility category including the expansion group (<=15-day gap allowance) between 2015 and 2017 (<30% of expansion enrollees switched eligibility groups at 6 months). These requirements ensure inclusion

of a year's worth of medical claims in our analytic sample and flexibly allow for inclusion of enrollees who change eligibility categories. Since our analysis is focused on patterns of utilization conditioned on some health care use, individuals who do not have at least one ED visit or one ambulatory care visit (as defined below) in the 12-month study period were removed from the analysis.

1.3.3 Outcomes: Emergency Department and Ambulatory Care Visits

There are two primary outcomes of interest: ED visits and ambulatory care visits, which form the basis of the trajectory analysis described below. Both ED and ambulatory care visit counts were generated at a person-month level. ED visits are identified using revenue codes and procedure codes and are defined by the presence of at least one outpatient facility claim for an ED visit not resulting in a hospital admission. Ambulatory care visits – visits that take place in offices, clinics, community health centers, or ambulatory surgical centers, are defined by the presence of a professional claim with an office/clinic place of service, a professional claim with the procedure code T1015 (a Federally Qualified Health Center visit), or a dental claim. Claims are counted at the enrollee-date-provider level, such that services performed by one provider on one day are considered a single visit.

1.3.4 Statistical Analysis

We analyzed the utilization data using group-based multi-trajectory modeling (GBMTM). GBMTM employs finite mixture modeling to group individual trajectories of multiple outcomes into meaningful subgroups.[16] GBMTM is unique from group-based trajectory modeling, which

examines one outcome at a time, and from dual group-based trajectory modeling, which estimates the conditional probabilities of following a trajectory for one outcome given that an individual follows a particular trajectory for the other outcome. Instead, GBMTM defines trajectory groups based on patterns in multiple outcomes. In this study, GBMTM was used to identify and group patterns of ED and ambulatory care visits to examine *joint* trajectory patterns of utilization over time and to characterize subgroups likely to follow these trajectories.

Before running the GBMTM, we examined the mean per-enrollee per-month count of ED and ambulatory care visits to properly identify the functional form of the outcomes. Ambulatory care visit counts were log-transformed and modeled as a censored-normal continuous distribution (later transformed back to their original scale using the Duan smearing estimate[17]), and ED visits were modeled as a zero-inflated Poisson distribution. We next ran group-based trajectory models for each of the outcomes (ED and ambulatory care use) separately. We fit models that found one, two, three, four, five, and six trajectory groups. To allow for flexibility in the shapes of the trajectories, the models included up to fifth-order polynomials for month of enrollment (the time variable), and the zero-inflated Poisson model included up to a fifth-order polynomial for the inflation factor. Because the goal of GBMTM is to identify distinct trajectories in the data, rather than a "true" number of groups, the goal of this activity is to identify the distinctive trajectories that should be represented in the final model and asses the minimum number of groups needed to include those trajectories (see Appendix A for additional details).[16]

Based on the above, we then assessed trajectory models including between four and six groups and evaluated these options based on model fit statistics (Bayesian information criterion and Akaike information criterion), as well as for substantive usefulness (see Appendix A).[16,18] Model adequacy was confirmed based on Nagin's criteria (see Appendix Table 2).[18-22]

1.3.5 Characteristics of Trajectory Groups

We described demographic and health status characteristics of the cohort and used chi-square tests and t-tests to compare trajectory groups. Demographic data included gender, age, race, region in Pennsylvania (based on managed care contracting regions), urbanicity (based on Rural–Urban Commuting Area<=3), and pre-expansion enrollment (2007-2014), which were extracted from monthly enrollment data (length of pre-expansion enrollment, if any, was broken into quartiles). Comorbidities diagnosed during the study were identified using the 19 diagnostic categories applied to adults in the calculation of Chronic Illness and Disability Payment System (CDPS) risk scores.[23] These comorbidities were extracted from ICD-9-CM and ICD-10-CM diagnostic codes in professional, outpatient, and inpatient claims and encounter data.

To establish the primary reasons for ED and ambulatory care visits, we used single-level Clinical Classification Software (CCS) developed by the Healthcare Cost and Utilization Project.[24,25] CCS allows us to group similar ICD-9 and ICD-10 diagnosis codes into a larger category for analysis. We assigned the CCS category to the primary diagnosis on each claim. Dental claims do not have diagnosis codes, so all claims with a dental procedure code (starting with "D") were assigned as "teeth and jaw" visits, relabeled "Dental."

In addition, we examined ED visits to identify those for ambulatory care sensitive conditions, which were potentially preventable given interventions in ambulatory care. We use ED Prevention Quality Indicators, which include conditions appearing frequently in the ED that may "reflect inadequate community health resources…or high disease burden or both," including non-traumatic dental conditions, acute ambulatory cellulitis, acute upper respiratory infections (URIs), flu or flu-like viruses, and visits for back pain.[26]

1.4 Results

1.4.1 Descriptive Analysis

Patient-level demographics are provided in Table 1 for the 601,877 enrollees who met study criteria (Appendix Table 1 includes a description of the excluded group compared to the study cohort). Under 5% of enrollees in each subgroup were enrolled in Medicaid on the same day as their first ED visits (data not shown). Half (52.3%) of enrollees in the sample used both ED and ambulatory care services in the first year of expansion enrollment. Enrollees were majority female (56.7%), non-Hispanic White (57.6%), and between the ages of 19 and 34 (50.7%). Most (86.84%) live in urban areas throughout the five regions of the state.

Table 1.1: Cohort Demographics

	n	%
	601,877	100%
Use of Services During Study Period		
Both ED & Ambulatory Care	315,074	52.3%
ED Only	42,598	7.1%
Ambulatory Care Only	244,205	40.6%
Sex		
Male	260,692	43.3%
Female	341,185	56.7%
Age		
19-34	305,213	50.7%
35-54	234,662	39.0%
55-64	62,002	10.3%
Race		
Non-Hispanic White	346,949	57.6%
Non-Hispanic Black	142,313	23.6%
Hispanic	64,982	10.8%
Other	47,633	7.9%
Health Choices Region		
Lehigh Capital	123,359	20.5%
New East	85,353	14.2%
New West	43,172	7.2%
Southeast	218,039	36.2%
Southwest	131,954	21.9%
Urbanicity		
Rural	76,777	12.8%
Urban	522,671	86.8%
Pre-expansion enrollment, 30+ days (2007-2014)		
Not previously enrolled	197,222	32.8%
Previously enrolled	404,655	67.2%
Previously enrolled for 30+ days (2007-2014):		
Children and Families	294,601	48.9%
Disabled	35,958	6.0%

Table 1.1 Continued

Chronically Ill	146,647	24.4%
Healthy Horizons	70,834	11.8%

1.4.2 Trajectory Analysis

Table 2 describes the subgroups identified by the trajectory analysis. Figure 1.1 illustrates the jointly-predicted trajectories of ambulatory care and ED utilization of each subgroup. A six-group model had the best characteristics based on BIC and substantive usefulness (see Appendix A), and met Nagin's criteria (Appendix Table 2).

Groups are numbered by decreasing size and, for ease of identification, are referred to below by their level of ED and ambulatory care use as compared to the other groups. Trajectories are considered "stable" unless there is a statistically significant difference between visit counts in month 1 and month 12.

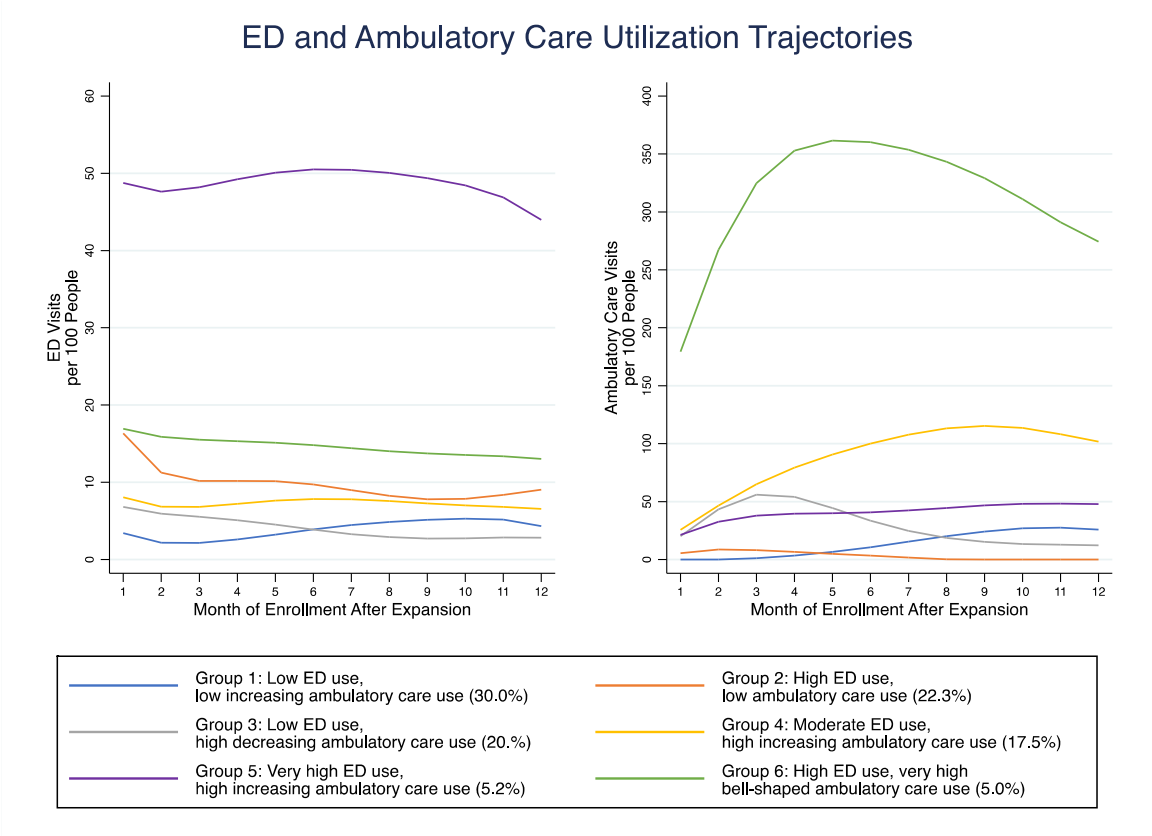

Figure 1.1: Ambulatory Care and ED Utilization Trajectories

Group 1: n=180,856 | Group 2: n=134,374 | Group 3: n= 120,369 | Group 4: n= 105,053 | Group 5: n= 31,268 | Group 6: n= 29,957

Trajectories for ambulatory care and emergency department visits were jointly identified using group-based multi-trajectory modeling (GBMTM). Ambulatory care visits were log-transformed and modeled as a censored-normal continuous distribution, then transformed back to their original scale using the Duan smearing estimate.

Table 1.2: Trajectory Subgroup Demographics

	Group 1		Group 2		Group 3		Group 4		Group 5		Group 6	
Number of Enrollees	180,856		134,374		120,369		105,053		31,268		29,957	
% of Sample	30.00%		22.30%		20.00%		17.50%		5.20%		5.00%	
Gender												
Female	106,320	59%	60,860	45%	71,071	59%	67,554	64%	18,548	59%	16,832	56%
Male	74,536	41%	73,514	55%	49,298	41%	37,499	36%	12,720	41%	13,125	44%
Age												
19-34	94,786	52%	82,674	62%	57,291	48%	40,989	39%	18,545	59%	10,928	36%
35-54	66,555	37%	43,579	32%	49,080	41%	48,166	46%	11,387	36%	15,895	53%
55-64	19,515	11%	8,121	6%	13,998	12%	15,898	15%	1,336	4%	3,134	10%
Race												
Non-Hispanic White	102,382	57%	69,053	51%	69,990	58%	67,606	64%	17,496	56%	20,422	68%
Non-Hispanic Black	42,002	23%	41,120	31%	26,355	22%	18,744	18%	9,071	29%	5,021	17%
Hispanic	18,687	10%	14,993	11%	13,126	11%	11,063	11%	3,718	12%	3,395	11%
Other	17,785	10%	9,208	7%	10,898	9%	7,640	7%	983	3%	1,119	4%
MCO Region												
Lehigh Capital	37,489	21%	27,634	21%	24,504	20%	22,030	21%	7,051	23%	4,651	16%
New East	25,392	14%	16,238	12%	17,904	15%	17,257	16%	4,489	14%	4,073	14%
New West	11,949	7%	8,972	7%	8,672	7%	8,095	8%	2,520	8%	2,964	10%
Southeast	67,954	38%	53,308	40%	43,063	36%	33,799	32%	10,379	33%	9,536	32%
Southwest	38,072	21%	28,222	21%	26,226	22%	23,872	23%	6,829	22%	8,733	29%
Urbanicity												
Rural	22,117	12%	14,578	11%	15,769	13%	15,629	15%	3,990	13%	4,694	16%
Urban	158,109	88%	119,284	89%	104,126	87%	88,987	85%	27,128	87%	25,037	84%

Table 1.2 Continued

Previous Enrollment												
Not previously enrolled	66,881	37%	43,779	33%	40,079	33%	34,444	33%	5,883	19%	6,156	21%
Previously enrolled	113,975	63%	90,595	67%	80,290	67%	70,609	67%	25,385	81%	23,801	79%
CDPS Combined												
Psychiatric	23,328	13%	16,459	12%	27,103	23%	40,961	39%	14,465	46%	20,531	69%
Cardiovascular	29,946	17%	17,106	13%	29,018	24%	36,152	34%	10,755	34%	11,319	38%
Skeletal and Connective	16,821	9%	11,324	8%	18,908	16%	30,992	30%	10,028	32%	11,439	38%
Substance Abuse	15,124	8%	19,503	15%	14,241	12%	17,067	16%	9,974	32%	12,168	41%
Gastrointestinal	16,578	9%	9,689	7%	18,140	15%	26,899	26%	9,613	31%	9,590	32%
Pulmonary	16,610	9%	14,306	11%	16,089	13%	22,449	21%	10,577	34%	8,394	28%
Diabetes	10,254	6%	4,471	3%	10,643	9%	14,896	14%	3,114	10%	4,709	16%
Skin	7,192	4%	8,379	6%	6,743	6%	9,883	9%	6,082	19%	4,013	13%
Nervous System	5,620	3%	4,169	3%	6,048	5%	10,711	10%	4,787	15%	4,914	16%
Genital	5,478	3%	2,895	2%	5,941	5%	8,734	8%	3,885	12%	2,650	9%
Count of CDPS Comorbidities												
No CPDS Comorbidities	89,468	49%	67,783	50%	37,299	31%	14,598	14%	3,189	10%	1,149	4%
1 CDPS Comorbidity	46,816	26%	36,099	27%	34,512	29%	22,726	22%	4,824	15%	4,921	16%
2 CDPS Comorbidities	24,492	14%	16,735	12%	23,495	20%	22,628	22%	5,828	19%	5,478	18%
3 CDPS Comorbidities	11,301	6%	7,455	6%	13,301	11%	18,089	17%	5,665	18%	5,216	17%
4+ CDPS Comorbidities	8,779	5%	6,302	5%	11,762	10%	27,012	26%	11,762	38%	13,193	44%

Note: All differences are statistically significant, p<.01.

Group 1 (180,856 enrollees, 24.4%) has a low, stable trajectory of ED visits with low ambulatory care use that starts to increase slightly around month 6. Group 2 (n=134,374, 18.1%) has high, stable ED use and low, decreasing ambulatory care use throughout the trajectory, averaging between 0 and 9 visits every 100 person months throughout the study period. Group 3 (n=120,369, 16.2%) has low, stable ED use, and initially high ambulatory care use per month that peaks in month three before decreasing through the rest of the year. Group 4 (n=105,053, 14.2%) has a moderate, stable trajectory of ED visits per month with initially low ambulatory care use (29.4 visits per 100 people in month 1) that increases during the study period, peaking at 115 visits per 100 people in month 9. Group 5 (n=31,268, 4.2%) had the highest ED use – around 50 visits per 100 people for most months of the study period, as well as initially high and increasing ambulatory care use, from 21 visits in month 1 to 48 visits per 100 people in month 12. Group 6 (n=29,957, 4.0%) has stable, high ED use and very high use of ambulatory care services that appear in a bell-shape, peaking at month 5 with 361 visits per 100 people.

1.4.3 Demographics of Trajectory Subgroups

Table 4 shows demographic characteristics of the trajectory subgroups. Subgroups were 45%-64% female. Age also varied between subgroups, with groups with higher ambulatory care use trending older. More than half (51%-68%) in each subgroup are white. There were slight differences in the regional composition of the subgroups, with the Southeast region (which includes Philadelphia) accounting for between 22% and 32% of enrollees in each group, and the Southwest region (which includes Pittsburgh) between 21% and 29% of the enrollees. Enrollees living in rural areas accounted for between 11% and 16% of the groups. Subgroups also have

varying histories of prior PA Medicaid enrollment, ranging from 63%-81% of enrollees in each group going back to 2007.

Table 4 also illustrates substantial differences among diagnosed comorbidities between groups. The table identifies the 10 CDPS categories that apply to the most enrollees in the overall population, listed in order. Half of the enrollees in Groups 1 (low-low) and 2 (high-low) do not have *any* comorbidities (49% and 50%, respectively), while nearly half (44%) of enrollees in Group 6 (high-very high) have four or more comorbidities. The prevalence of psychiatric diagnoses varied markedly from 12% (Group 2, high-low) to 69% (Group 6, high-very high). Cardiovascular diagnoses, ranging from hypertension to congestive heart failure and heart transplant, also vary by subgroup, from 13% of Group 2 (high-low) enrollees to 38% of Group 6 (high-very high) enrollees.

1.4.4 Reasons for Ambulatory Care Utilization Among Subgroups

There were 5,270,320 visits to ambulatory care providers in the study cohort. Figure 2 shows the top 5 reasons for ambulatory care visits in each subgroup. Ambulatory care visits for dental care were extremely common among all subgroups: nearly one of five ambulatory visits among enrollees in groups 1 (low-low) and 2 (high-low) were for dental care (18% and 17%, respectively). The CCS category "Medical exam" refers to general medical and gynecological exams. Between 6% and 11% of the ambulatory care visits for Groups 1 (low-low), 2 (high-very low), and 3 (low-high) were for medical exams. "Vision defects" are primarily visits for myopia, making up 5%-8% of visits for Groups 1 (low-low) and 2 (high-very low) enrollees.

The proportion of visits for mood disorders, including major depression and bipolar disorder ranged from 4% in Groups 1 (low-low) and 2 (high-low) to 21% among enrollees in

Groups 4 (moderate-high) and 6 (high-very high). Visits for drug use and dependence (referred to as the "substance-related disorders" CCS category) were a common diagnosis for almost all groups, with the category comprising nearly one-third (30%, or 1,596 visits per 100 people during the study period) of the ambulatory care visits for Group 6 (high-very high). Other common reasons for ambulatory care visits include anxiety disorders and back problems.

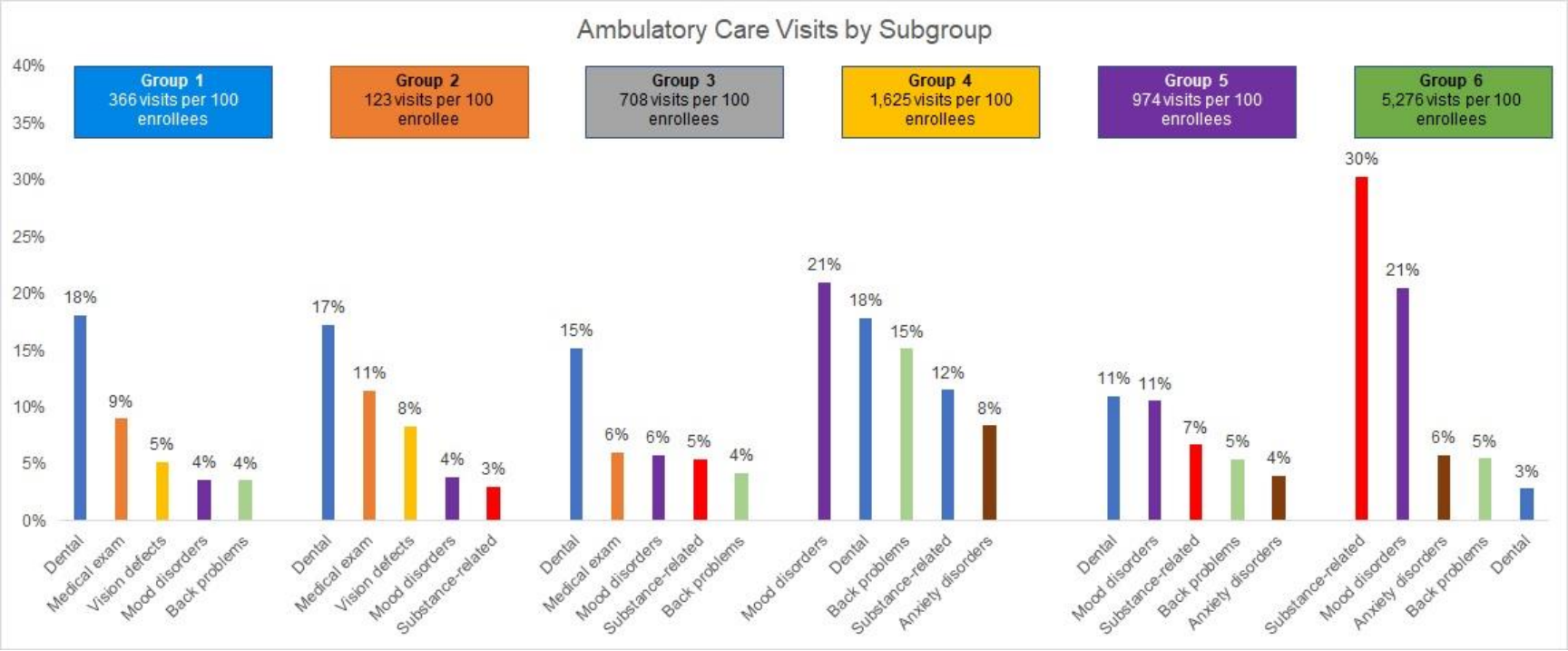

Figure 1.2: Reasons for Ambulatory Care Visits

Group 1: n=661,088 visits | Group 2: n=165,190 visits | Group 3: n=852,024 visits | Group 4: n=1,706,774 visits | Group 5: n=1,580,603 visits | Group 6: n=5,270,320 visits. To establish the primary reasons for ED and ambulatory care visits, we used single-level Clinical Classification Software (CCS) developed by the Healthcare Cost and Utilization Project. CCS allows us to group similar ICD-9 and ICD-10 diagnosis codes into a larger category for analysis. We assigned the CCS category to the primary diagnosis on each claim. Dental claims do not have diagnosis codes, so all claims with a dental procedure code (starting with "D") were assigned as "teeth and jaw" visits.

1.4.5 Reasons for ED Utilization and Ambulatory Care Sensitive Conditions

While the reasons for ambulatory care visits were markedly different across subgroups, the top reasons for visiting the ED were very similar. Figure 3 displays the top 5 diagnoses during ED visits in each subgroup. There were 648,584 visits to the ED by enrollees during the study period. ED visits for sprains and strains and abdominal pain are the most common. Upper respiratory infections, back problems, and teeth and jaw diagnoses are among others that most frequently bring expansion enrollees to the ED. Some ED visits were classified as "potentially preventable" ambulatory care sensitive conditions that may have been resolvable in ambulatory care settings (Figure 4). For all measured diagnoses, potentially preventable visit rates ranged from 3.6 visits/100 enrollees among Group 1 enrollees (low-low) to 52.7 visits/100 enrollees among Group 5 enrollees (very high-high). Group 5 (very high-high) had substantially more visits for every diagnosis, including non-traumatic dental conditions (20.9 visits/100 enrollees versus 1.3/100 in Group 1, low-low), acute URIs, colds, and allergies (17.4/100 versus 1.6/100), and at least two ED visits for back pain (6.8/100 versus 0.1/100). Group 2 (high-low) and Group 6 (high-very high) also had high rates of potentially preventable visits (11.3 visits/100 enrollees and 11.6 visits/100 enrollees, respectively).

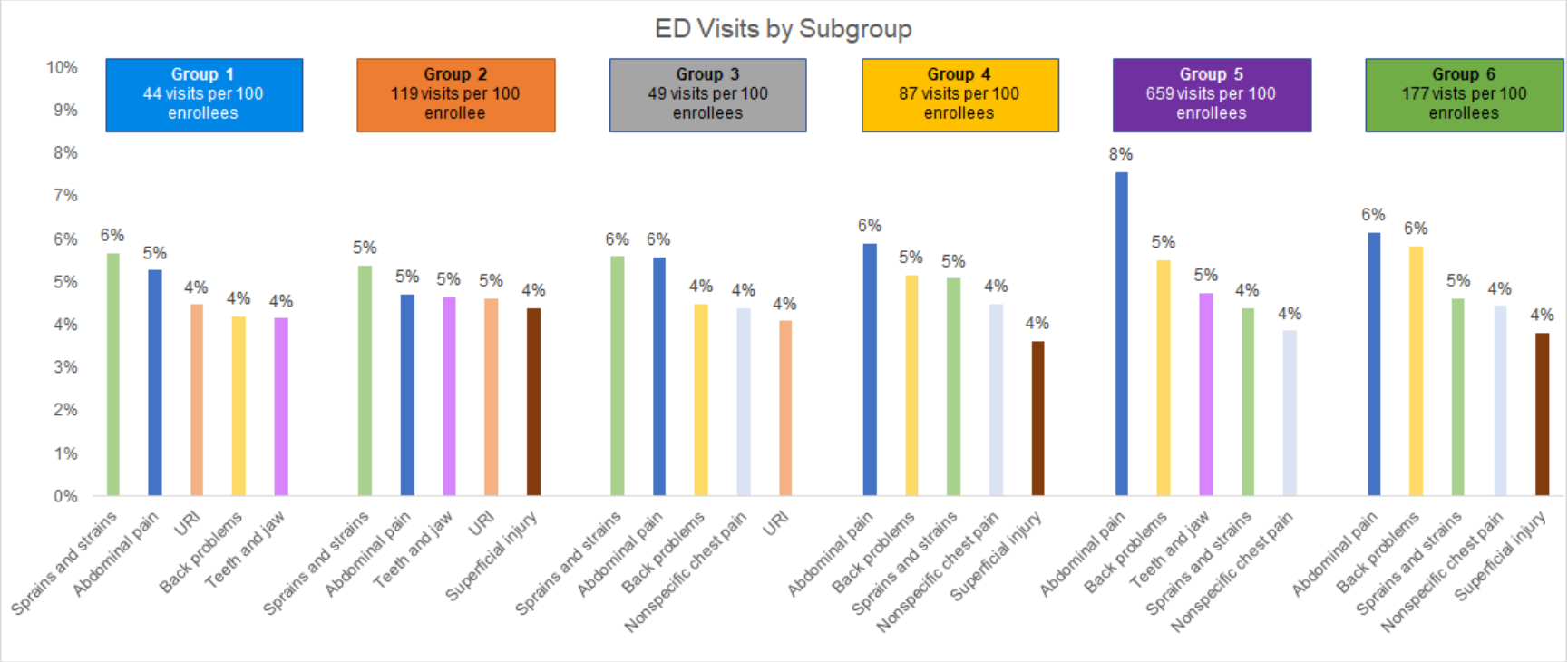

Figure 1.3: Reasons for ED Visits

Group 1: n=79,350 visits | Group 2: n=160,180 visits | Group 3: n=58,563 visits | Group 4: n=91,431visits | Group 5: n=206,124 visits | Group 6: n=52,936 visits. To establish the primary reasons for ED and ambulatory care visits, we used single-level Clinical Classification Software (CCS) developed by the Healthcare Cost and Utilization Project. CCS allows us to group similar ICD-9 and ICD-10 diagnosis codes into a larger category for analysis. We assigned the CCS category to the primary diagnosis on each claim.

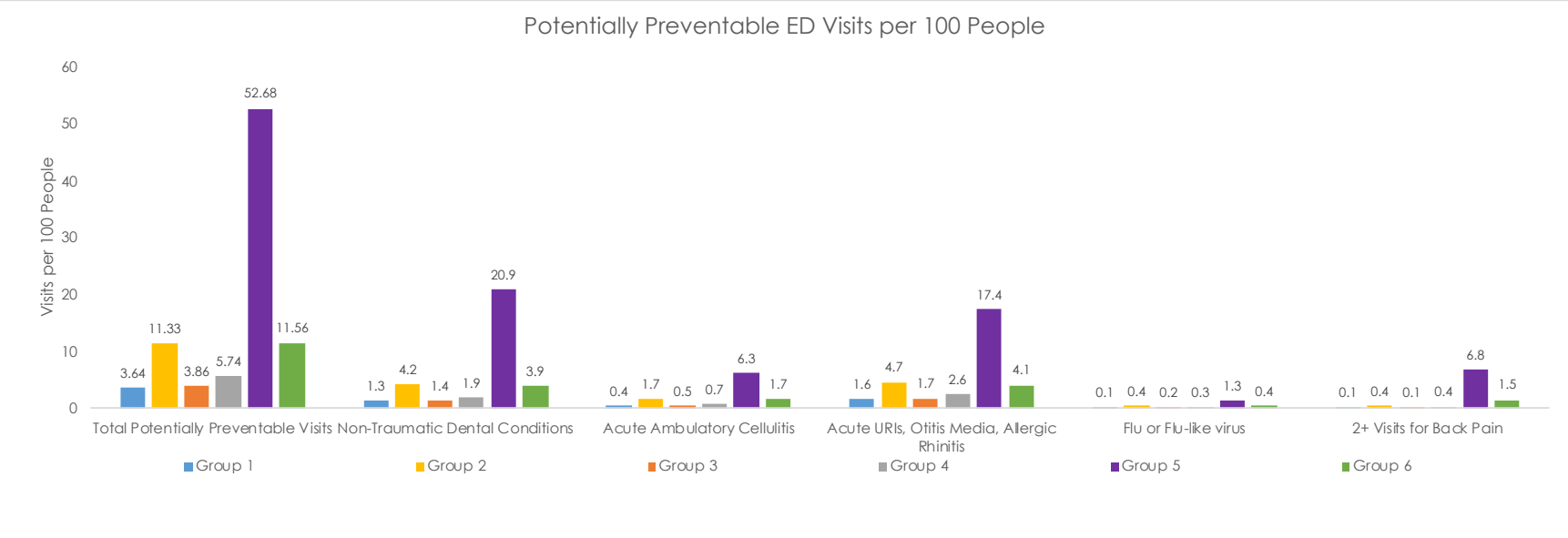

Figure 1.4: Potentially Preventable ED Visits per 100 Enrollees

Visits are potentially preventable given interventions in ambulatory care.

1.5 Limitations

First, while Pennsylvania is one of the largest states in the country and has demographics resembling national averages, the data used in this study are specific to Pennsylvania and results may not be generalizable to other states. The method used for this analysis, however, is broadly applicable. Second, our analysis relies on Medicaid claims and enrollment data during the study period. Because enrollee comorbidities are identified using diagnosis codes assigned during the study period, it is not possible to determine if a group with low health service use and few comorbidities is healthy or simply not engaged in care. Additionally, we cannot account for any additional care received by enrollees that was not financed by Medicaid. Third, we do not measure "appropriate" utilization; any value assigned to these changes in use are assumptions based on prior literature.[27,28] Finally, because we are only examining patterns of ED and ambulatory care use post-expansion, we cannot comment on changes before vs. after the ACA.

1.6 Discussion

Medicaid expansion has been implemented in 37 states and the District of Columbia, and several years into expansion, research findings on ED use in the expansion population continue to be mixed, identifying both increasing and stable use.[5-11] By explicitly addressing heterogeneity using trajectory analyses, we identified six distinct groups of Medicaid expansion enrollees who use care differently, both in the level of ED and in ambulatory care use, as well as the underlying health needs being met with these visits, and rate of potentially preventable ED encounters. This

heterogeneity may partially explain divergent prior research regarding how Medicaid expansion impacted use of the ED.

Three groups had relative decreases in ED use of 20% of greater in the first 12 months of Medicaid expansion enrollment (although no changes were statistically significant). There were also large changes in ambulatory care use: four groups had at least a 50% increase in ambulatory care visits during the study period, and the largest group, Group 1 (low-low), had the largest relative increase in ambulatory care visits. This may reflect individuals becoming engaged with the health care system and being able to access ambulatory care for the first time, and suggests that providers accepting Medicaid had adequate capacity to meet the increased demand for care, but it is not necessarily linked with decreasing ED use, at least in the short run.

Our approach can be useful for targeting subgroups for interventions. For example, we found two subgroups of high utilizers – Groups 5 (very high-high) and 6 (high-very high) with a high prevalence of psychiatric and substance use disorders as well as cardiovascular comorbidities. In particular, a misalignment of chronic condition diagnoses and the recorded diagnoses for ambulatory care visits occurs in group 5 (very high-high), which also has the highest rate of potentially preventable ED visits. These groups may benefit from integrated care models for behavioral health and physical health conditions, some of which have been shown to reduce ED use.[29] Expansion states now have up to 5 years of experience with their Medicaid expansion populations and may be able to adopt our approach to identify similar subgroups who may benefit from intervention. Care management strategies, which combine integrated care with enhanced management of specific conditions, may be particularly beneficial for managing the comorbidities in these groups. In the second half of the study period, Pennsylvania introduced Centers of Excellence (COE) for Opioid Use Disorder, which combine OUD treatment, physical and mental

health treatment, peer support, and care coordination across all domains.[30] In the first year, 62% of individuals seen by a COE engaged in non-emergency treatment for at least 30 days.[31] Extensions of this model may improve treatment for individuals with high rates of both behavioral health and physical health conditions, decreasing the number of ED visits.

To our knowledge, this is the first study to use data-driven methods to examine distinct patterns in longitudinal health care service use among Medicaid expansion enrollees. Among six heterogenous groups of Medicaid expansion enrollees, we saw stable but markedly different levels of ED use, as well as temporal variation in ambulatory care visits. Additionally, we identified heterogeneity among the underlying health needs being met from these visits and in the rate of potentially preventable ED encounters. Medicaid programs and their managed care contractors may use data-driven approaches such as trajectory analyses to segment Medicaid expansion populations to determine how best to direct resources to encourage appropriate use of expensive ED services and support enrollees' engagement with ambulatory care providers.

2.0 Changes in Medicaid Utilization and Spending Associated with Homeless Adults' Entry into Permanent Supportive Housing

2.1 Abstract

Importance: There is growing interest in financing housing and supportive services for homeless individuals through Medicaid programs. Programs like Permanent Supportive Housing (PSH), which integrate non-time-limited housing with supportive services for people who are disabled and chronically homeless, have seen rapid growth in the last decade, but clear evidence on the long-term impacts of PSH, needed to guide state efforts to finance some PSH services through Medicaid, is lacking.

Objective: To assess changes in Medicaid expenditures and utilization associated with receiving PSH.

Design: We linked Homeless Management Information System (HMIS) data from 54 of Pennsylvania's 67 counties to Medicaid enrollment and claims at the person-level. We identified a cohort of adult Medicaid enrollees who entered PSH between 2011 and 2016 and assessed changes in their healthcare expenditures and utilization from up to 15 months before to up to three years following PSH entry. Using a difference-in-differences approach, we compared these changes to trends in a propensity score-matched cohort of adults experiencing housing instability who did not receive PSH.

Setting: Pennsylvania Medicaid

Participants: 1,226 PA Medicaid enrollees who entered PSH during the period 2011-2016 and remained in PSH for at least 180 days and a matched comparison cohort of 970 enrollees experiencing housing instability who did not receive PSH.

Exposure: Receipt of PSH.

Main Outcomes: Medicaid spending, in aggregate, and on behavioral and physical health services; emergency department (ED) visits and inpatient hospital stays.

Results: Three years after PSH entry, spending decreased by an average of $145/month in the PSH cohort relative to changes in the comparison cohort (p=0.046), with the greatest relative spending reductions occurring for residential behavioral health ($64, p<0.001), community behavioral health ($40, p=0.015), and inpatient non-behavioral health services ($89, p=0.001). Consistent with these spending declines, we found relative reductions in ED use (4.7 visits/100 person-months, p=0.010) inpatient hospital stays (1.6 visits/100 person-months, p<0.001) in the PSH vs. comparison groups after 3 years.

Conclusions and Relevance: These results can inform emerging state efforts to finance PSH services through Medicaid. Additional state expenditures to expand financing for PSH services could be partially offset by reductions in Medicaid spending when Medicaid enrollees are stably housed, and may shift treatment to outpatient as opposed to acute care settings.

2.2 Background

There is growing interest in financing housing and supportive services for homeless individuals through the Medicaid program.[32] Homeless populations' high burden of serious mental health conditions, substance use disorders (SUD), and chronic physical health conditions

contribute to elevated rates of hospital and emergency department (ED) use, the costs of which may disproportionately accrue to Medicaid.[33] To improve health outcomes in homeless individuals and reduce expenditures, Medicaid programs are interested in whether they could realize savings by addressing health needs linked to homelessness, through strategies such as financing support services to help individuals receive and maintain stable housing.

Programs like Permanent Supportive Housing (PSH) have attracted interest from policymakers and experienced rapid growth in the last decade.[34] PSH integrates non-time-limited housing with supportive services for people who are disabled and chronically homeless. These supportive services can include relocation assistance, tenancy sustaining services, SUD and mental health treatment, and employment assistance.[35]

Medicaid programs can pay for supportive services in PSH that fall outside the scope of traditional health benefits, but cannot pay for routine room and board costs. Several states are considering options to finance a greater share of PSH costs through their Medicaid programs,[35] which typically require a waiver of program rules and demonstration of budget neutrality or cost-effectiveness over the term of the waiver (typically 2-5 years).[35,36]

However, there is limited evidence on the long-term impacts of PSH on health services utilization and expenditures. Several studies have linked receiving PSH to reductions in inpatient and ED use and increases in behavioral health care utilization in populations with serious mental health diagnoses, but other analyses found few changes in health care spending attributable to PSH.[35,37-47] A recent report by the National Academies of Science, Engineering, and Medicine cited a lack of clear evidence on the long-term impacts of PSH, noting that existing studies were limited by small samples and follow-up periods of less than two years—shorter than most individuals' duration of PSH enrollment and the period over which the benefits of stable housing

might accrue both to residents and Medicaid.[35,41-43,48-53] In addition, previous studies are primarily small and geographically heterogenous.[35]

We address these limitations of prior research by studying a cohort of 1,226 geographically diverse PSH recipients enrolled in Pennsylvania Medicaid during 2011-2017, among whom we assessed changes in Medicaid expenditures and utilization from up to 15 months before to three years following PSH entry. We compared these changes to trends in a matched cohort of individuals experiencing housing instability who did not receive PSH using a difference-in-differences analysis.

2.3 Methods

2.3.1 Data

We analyzed Medicaid enrollment and claims data from the Pennsylvania Medicaid program linked to Homeless Management Information Systems (HMIS) records from 54 of Pennsylvania's 67 counties for the period 2011-2017. The HMIS captures Department of Housing and Urban Development (HUD)-financed housing services provided to individuals and families who are homeless or at risk of homelessness.[54] HMIS data include information about housing service dates (e.g., PSH entry and exit) and capture the provision of short-term housing services (e.g., overnight shelters) separate from PSH.

HMIS and Medicaid data were matched by the Pennsylvania Department of Human Services using individual-level identifiers (Social Security Numbers and birth date).[55] Our linked Medicaid-HMIS data encompassed Pittsburgh, the majority of Pennsylvania's rural counties, and

several midsized urban areas. We were unable to obtain housing data for some of Pennsylvania's most populous counties, including Philadelphia, who directly manage their HMIS systems (Appendix).

2.3.2 PSH Sample

We identified Pennsylvania Medicaid enrollees who entered a PSH program between April 1, 2012 and December 31, 2016, were age 21 or older at the time of PSH entry, and stayed in PSH for at least 180 days, consistent with this program's goal of providing long-term housing.

Because we sought to analyze changes in Medicaid utilization and spending before and after PSH entry, we required individuals to meet minimum Medicaid enrollment criteria in three time periods: a pre-baseline period (16-28 months before PSH entry); a baseline period (7 to 15 months before PSH entry); and the year immediately after PSH entry (Appendix Table 1). We required PSH recipients to have been enrolled in Medicaid for at least 4 months in the pre-baseline period to asses established health conditions, 6 months during the baseline period, and at least 6 months in the first year following PSH entry. This allowed us to assess the pre-PSH characteristics of Medicaid enrollees and to examine changes in their Medicaid spending and utilization before and after PSH entry while recognizing that it is common for individuals to have some gaps in Medicaid coverage.[56]

2.3.3 Comparison Sample

We identified a comparison sample of Medicaid enrollees with similar demographic and health characteristics as PSH recipients who did not receive PSH, but who received other housing

services indicative of episodic or chronic homelessness (e.g. emergency shelter stays). The comparison sample controls for secular trends in spending and utilization, other than those likely precipitating PSH entry, that would have been expected if adults had not received PSH. We identified this comparison sample in two stages.

First, among Pennsylvania Medicaid enrollees who received housing services other than PSH, we used propensity score matching to identify an initial comparison group of individuals who resembled PSH recipients on time-invariant characteristics (e.g. gender, race), including chronic conditions (e.g. SUD diagnosis, diabetes), reported on Medicaid claims between 2011 and 2017. For each PSH recipient, we selected up to four comparison individuals within a quantile of a propensity score which summarized individuals' propensity to receive PSH given their characteristics (Appendix).

Second, we identified a reference month for each individual in the comparison sample identified in step 1. We selected this reference month so that spending trends in the 7-15 months preceding it most closely resembled those of PSH recipients in the 7-15 months prior to PSH entry. We focused on this period because it generally preceded marked increases in Medicaid spending 1-6 months before that was common in adults in our intervention group receiving PSH. These spending increases were concentrated in behavioral health treatment and may reflect events facilitating entry into PSH (e.g., a residential treatment stay) or health system engagement to obtain medical documentation of a disability, a prerequisite for PSH eligibility. Few adults in our candidate comparison sample incurred similar increases in spending, furthering our belief that this spending is directly related to receiving PSH. Therefore, we excluded spending and utilization in the 1-6 months prior to PSH entry, and the 1-6 months prior to the reference month in our

comparison sample, from our analyses.[23] We discuss implications of this matching strategy for our statistical analyses below and in the Appendix.

2.3.4 Outcome Measures

We used Medicaid claims and encounter data to assess spending and utilization. We measured Medicaid spending using paid amounts in managed care and fee-for-service claims. We analyzed spending in total, in three major service categories – behavioral health, physical health, and pharmacy spending – and in subcategories, including community, residential, and inpatient behavioral health visits; ED visits; and acute care inpatient visits, among others, based on prior literature. As housing may affect use of a broad set of health care services, we also analyzed 18 measures of utilization, including ED use, residential behavioral health treatment, behavioral health and acute care inpatient stays, and primary care visits, among other, based on prior literature (Appendix).[38,43,57-60]

2.3.5 Statistical Analysis

We conducted difference-in-difference analyses to compare changes in spending and utilization from baseline (7-15 months prior to PSH entry, or the reference month for the comparison cohort) to up to 3 years following PSH entry among PSH recipients to changes in the comparison group following the reference month. The unit of analysis was the person-month.

For spending outcomes, we estimated differential changes between the PSH and comparison cohorts over time using a two-part regression model: a probit model to account for person-months with no spending and a generalized linear model with a log link and gamma

variance function for months in which individuals incurred >$0 in spending. For utilization measures, we used linear models (Appendix). We adjusted for age, gender, race/ethnicity, urbanicity, county, and time-varying chronic health conditions. Standard errors were clustered at the person level to account for correlation between months within individuals. We report adjusted differential changes in per member per month spending or utilization between the PSH and matched comparison samples from baseline (7-15 months prior to PSH entry) through the first, second, and third year following PSH entry.

2.3.6 Sensitivity and Supplementary Analyses

We conducted a sensitivity analysis that further omits the three months of the baseline period closest to PSH entry (7 to 9 months prior to PSH entry) to avoid picking up any pre-enrollment increases in spending that might cause us to conflate long-run spending changes with regression to the mean effects.

We conducted two supplementary analyses. First, we compared the characteristics of individuals who remained enrolled in Medicaid three years after PSH entry (intervention group) and three years after the reference month (comparison group). To the extent Medicaid attrition is lower among PSH recipients with chronic health conditions that predispose individuals to need more care than it is among individuals in the comparison cohort, our estimates may be biased away from finding reductions in spending and changes in utilization associated with receiving PSH. Second, we examined spending trends prior to the baseline period in the PSH and comparison cohorts to evaluate whether long-run spending trends were similar prior to the baseline period. This establishes that secular spending trends—excluding increases in spending preceding PSH entry—would likely have remained similar had our treatment sample not received PSH.

2.4 Results

2.4.1 Cohort Demographics and Health Status

Among PSH recipients in our cohort (n =1,226), 58.1% were female, 74.1% lived in Southwestern Pennsylvania, and 30.2% were non-Hispanic Black. Behavioral health burden was high in our cohort with 95.0% diagnosed with a mental illness and 66.2% with an SUD. More than a quarter (25.4%) had been diagnosed with the hepatitis C virus (HCV). As expected, the matched comparison population (n=970) closely resembled PSH recipients (Table 1).

Table 2.1: Demographic Characteristics

	PSH Cohort (n=1226)		Comparison (n=970)		p-value[1]
	N	% within cohort	N	% within cohort	
Female, %	712	58.1	563	58.0	0.987
Age, % in category					
22-34	469	38.3	435	44.8	0.001*
35-44	291	23.7	239	24.6	
45-54	321	26.2	214	22.1	
55+	145	11.8	82	8.5	
Race, % in category					
Non-Hispanic White	802	65.4	606	62.5	0.161
Non-Hispanic Black	370	30.2	326	33.6	
Hispanic	35	2.9	-*	-*	
Other	19	1.5	-*	-*	
Medicaid Managed Care Contracting Region, % in category					
Lehigh	106	8.6	97	10.0	0.869
New East	64	5.2	52	5.4	
New West	132	10.8	102	10.5	
Southeast	16	1.3	13	1.3	
Southwest	908	74.1	706	72.8	
Resident of Allegheny County, %	686	56.0	521	53.7	0.294
Resident of rural county %[2]	370	30.2	307	31.6	0.459
Dual enrollee in Medicare and Medicaid, % [3]	83	6.8	65	6.7	0.949
Eligible for Medicaid through a disability pathway, %[4]	559	45.6	427	44.0	0.461
Diagnoses, %					
Hepatitis C Virus	312	25.4	232	23.9	0.409
Human Immunodeficiency Virus	31	2.5	22	2.3	0.693
Tobacco use disorder	1,028	83.8	805	83.0	0.590
Substance use disorder	811	66.2	629	64.8	0.523

Table 2.1 Continued

Mental health diagnosis	1,165	95.0	923	95.2	0.889
Cardiovascular disease, extra low[5]	663	54.1	539	55.6	0.486
Gastrointestinal, low[5]	711	58.0	541	55.8	0.297
Infectious, low[5]	395	32.2	296	30.5	0.393
Cardiac disease[5]	693	56.5	538	55.5	0.619
Diabetes[5]	200	16.3	152	15.7	0.683

[1]P-value for differences in proportions between the PSH and comparison cohorts. Differences were assessed using Chi-square tests for categorical variables.
[2]Rurality was assessed at the county level according to a definition provided by The Center for Rural Pennsylvania.
[3]If an enrollee had >=1 month in the years 2011-2017 in which they were dually enrolled in Medicare and Medicaid, they were considered to have been a dual enrollee Medicare and Medicaid.
[4]If an enrollee had >=1 month in the years 2011-2017 in which they were enrolled in Medicaid through a disability pathway, they were considered to have been enrolled through a disability pathway.
[5]Categories were assessed using the Chronic Illness & Disability Payment System and Medicaid Rx (CDPS-MRX). "Low" and "extra low" refer to levels of severity. Categories listed here are the top 5 CDPS-MRX categories present in the PSH cohort.
*Cell values haves been suppressed due to small cell sizes.

2.4.2 Unadjusted Estimates

At baseline (7-15 months prior to PSH entry), average monthly Medicaid spending among individuals in the PSH group was $1,337 and declined to $1,262 in the third year following PSH entry. In the comparison group, average spending increased from $896 at baseline (7-15 months prior to their reference month) to $1,038 in year 3 (Figure 3.1). The unadjusted differential decline in monthly spending was $218. From baseline to year 3, we found differential declines in behavioral health ($166/monthly per person) and physical health spending ($100/monthly per person), but relative increases in pharmacy spending ($61/monthly per person) in the PSH versus comparison cohorts.

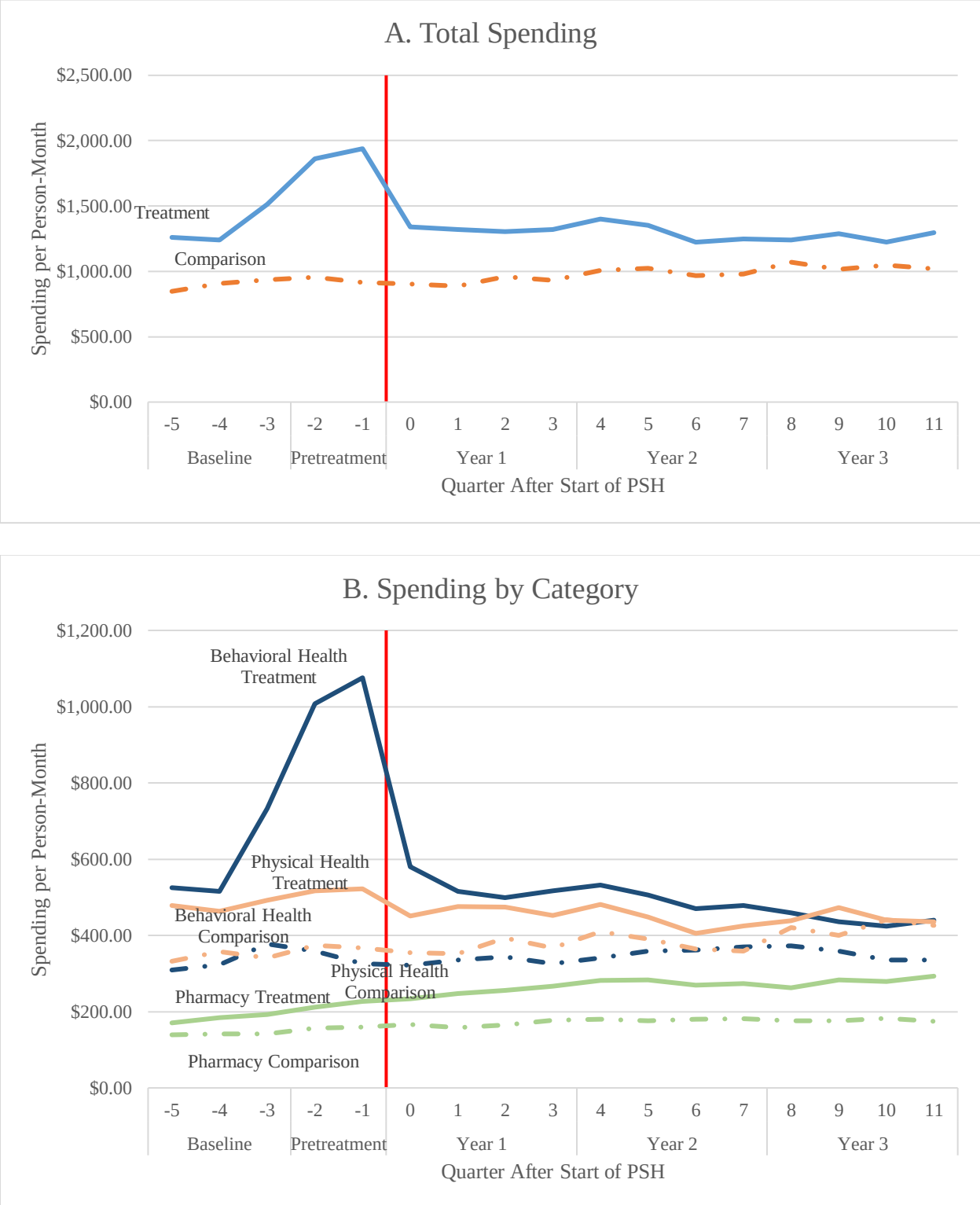

Figure 2.1: Unadjusted Spending

Unadjusted spending from 15 months prior to the start PSH (or the index date, for the comparison group) until 35 months after the start of PSH. Unadjusted spending is calculated as a total of paid amounts on all claims included in the category. Total spending includes all claims during the study period.

2.4.3 Adjusted Estimates

Prior to PSH entry, we observed spending increases in the PSH group, which were concentrated primarily in the six months before PSH entry and among behavioral health services. We excluded these months, and the six months before the reference date in the matched comparison sample, from our estimates of adjusted spending changes.

Adjusted monthly spending among PSH recipients declined from approximately $1,228 in the baseline period to $1,156 in year three but increased among individuals in the comparison cohort from $957 in baseline to $1,030 in year 3. The relative decline in total spending from baseline to year 3 in the PSH versus comparison cohorts was -$145 (CI [-$289, -$3]; p=.046) (Table 2A and Appendix). Relative declines in spending were seen for total behavioral health (-$119; CI [-$191, -$48]; p=.001) and physical health services (-$73; CI [-$133, -$13]; p=.017), attributable primarily to decreases in residential behavioral health (-$64; CI [-$95, -$34]; p=.000) and community behavioral health (-$40; CI [-$72, -$8]; p=.015), and inpatient non-behavioral health care spending (-$89; CI [-$139, -$39]; p=.001).

Spending also changed proportionally between the baseline period and year 3 (Figure 2). Outpatient pharmacy spending increased from 17.4% to 26.8% of total spending, and case management increased from 5.3% to 8.9%. Residential behavioral health (11.5% to 3.8%),

inpatient behavioral health (6.5% to 3.6%), and inpatient non-behavioral health (19.4% to 15.3%) spending all proportionally declined between the baseline period and year 3.

The number of ED visits was nearly equal between the PSH cohort and comparison cohort during the baseline period, but relative declines occurred among the PSH cohort in all three years following PSH entry for a total decline of 4.7 visits per 100 person-months by year 3 (CI [-8.3,-1.0], p=.010, 20% from baseline) (Table 2B and Appendix). There was also a relative decline in acute care hospitalizations in all three years (1.6 fewer visits per 100 person-months by year three; CI [-2.5, -0.7]; p=.000; 42% decrease) and days spent in residential SUD treatment (27.3 fewer days by year three; CI [-42.4,-12.2]; p=.000; 71% decrease). In contrast, the number of community mental health visits increased among the PSH cohort relative to the comparison cohort in years one and two (increase of 87.0 visits per 100 person-months in year one; CI [66.1, 107.8]; p=.000). Almost all spending measures show similar changes in spending in the sensitivity analysis as compared to the original analysis.

Table 2.2: Relative Changes in Spending from Baseline: PSH enrollees versus matched controls

	Baseline, per Person-Month (Months -15 to -7)		Year 3 Differential Change from Baseline, PSH vs. Comparison (Months 24 to 35)			
	PSH Cohort	Comp. Cohort	PSH Cohort[1]	Comp. Cohort[2]	Difference (Bootstrapped 95% CI)	p-value[3]
Total	$1,228.19	$956.71	-$72.53	$72.92	-$145.45 (-$288.80, -$3.37)	0.046
Behavioral Health[4]	$511.85	$336.69	-$118.34	$0.59	-$118.93 (-$190.50, -$47.79)	0.001
Physical Health[5]	$415.36	$347.02	-$23.58	$49.11	-$72.69 (-$132.80, -$13.23)	0.017
Pharmacy	$169.44	$143.07	$66.12	$33.79	$32.34 ($1.03, $64.71)	0.047
ED	$51.14	$45.76	-$12.56	-$4.26	-$8.30 (-$16.04, -$0.83)	0.032
Case Management	$51.50	$27.69	$26.44	$6.04	$20.40 ($7.07, $33.93)	0.003
Community Behavioral Health	$199.14	$116.03	-$16.23	$23.35	-$39.58 (-$71.51, -$8.00)	0.015
Residential Behavioral Health	$111.80	$72.49	-$78.43	-$13.83	-$64.61 (-$95.33, -$33.63)	0.000
Inpatient Non-Behavioral Health	$188.66	$117.79	-$53.99	$35.21	-$89.20 (-$139.40, -$38.57)	0.001

[1]Spending difference between baseline spending among PSH cohort and given year spending among PSH cohort.
[2]Spending difference between baseline spending among comparison cohort and given year spending among comparison cohort.
[3]P-value for differences in proportions between the PSH and comparison cohorts.
[4]Includes community behavioral health, case management, residential behavioral health, and inpatient behavioral health spending.
[5]Includes ED, non-behavioral health inpatient, primary care, other physician services, other ambulatory care services, and other spending.

Table 2.3: Relative Changes in Utilization from Baseline: PSH enrollees versus matched controls

	Baseline, per Person-Month (Months -15 to -7)		Year 3 Differential Change from Baseline, PSH vs. Comparison (Months 24 to 35)			
	PSH Cohort	Comp. Cohort	PSH Cohort[1]	Comp. Cohort[2]	Difference (95% CI)	p-value[3]
ED visits	23.59	21.56	-7.23	-2.57	-4.66 (-8.29, -1.04)	0.010
Acute care hospitalization visits	3.77	2.50	-1.45	0.15	-1.60 (-2.47, -0.73)	0.000
Primary Care visits	27.10	24.60	-0.07	-3.96	3.89 (-0.48, 8.25)	0.080
Community Mental Health treatment days	184.13	107.20	28.88	12.10	16.79 (-11.76, 45.33)	0.250
Community Substance Use Disorder treatment days	93.23	61.82	-9.20	11.38	-20.58 (-56.74, 15.59)	0.260
Residential mental health treatment days	0.20	3.31	-0.33	-2.93	2.61 (-1.18, 6.40)	0.180
Residential substance use disorder days	38.47	20.80	-23.75	3.57	-27.32 (-42.44, -12.20)	0.000
Inpatient mental health treatment days	2.79	2.22	-1.41	-0.61	-0.80 (-1.65, 0.05)	0.070
Inpatient substance use disorder treatment days	0.10	0.09	-0.07	-0.04	-0.03 (-0.15, 0.09)	0.640

[1]Utilization difference between baseline spending among PSH cohort and given year spending among PSH cohort.
[2]Utilization difference between baseline spending among comparison cohort and given year spending among comparison cohort.
[3]P-value for differences in proportions between the PSH and comparison cohorts.

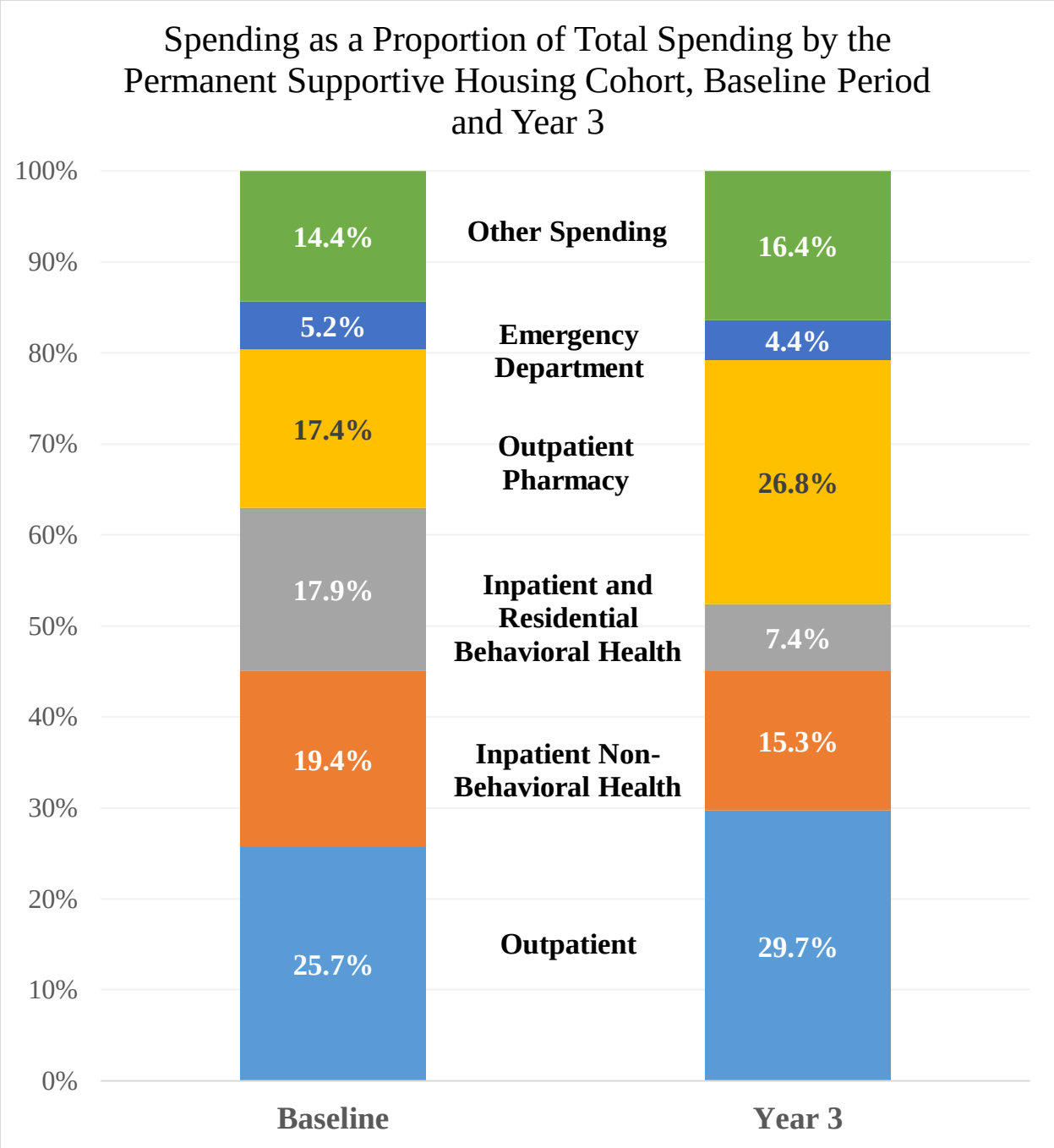

Figure 2.2: Spending as a Proportion of Total Spending by the Permanent Supportive Housing Cohort, Baseline Period and Year 3

Adjusted spending as a proportion of total spending in the baseline period (7-15 months prior to entering PSH) and in the third year after entering PSH. Outpatient pharmacy spending and case management become a larger proportion of overall spending by year 3. Residential behavioral health care, inpatient behavioral health, and inpatient non-behavioral health become a smaller proportion of overall spending by year 3. Because we top-coded each spending variable to the 99th percentile to limit the influence of high-cost outliers, percentages may not align with calculated percentages in other figures.

2.4.4 Supplementary Analyses

A supplementary analysis examined the demographics of those who were still enrolled in Medicaid at Month 35 in the PSH versus comparison groups (Appendix). If a higher proportion of individuals who remained in the PSH group had chronic condition diagnoses versus the comparison group, we would expect our results to be biased away from finding reductions in spending and changes in utilization associated with PSH. However, there is no difference in proportion of enrollees diagnosed with a variety of chronic conditions between 2011 and 2017.

We also examined differential spending prior to the baseline period to establish that the long-run trend in spending between the PSH and comparison cohorts was similar prior to the pre-treatment period. Two unadjusted models for spending in in the 16 to 27 months prior to PSH show no difference in the trend in total spending, providing additional support for the assumption that long-run trends would have been expected to remain similar had our treatment sample not received PSH (Appendix).

2.5 Discussion

We analyzed a cohort of adults enrolled in Pennsylvania Medicaid who received PSH and a matched comparison group of unstably housed individuals who did not receive PSH to estimate long-term changes in Medicaid spending and utilization associated with receiving PSH. We estimated that, three years after entering PSH, monthly Medicaid spending was $145 per person lower than would have been expected had enrollees not entered PSH, a 12% reduction from mean spending in the 7 to 15 months before individuals received PSH. This amounts to a relative

spending reduction of $1740 per person in the third year after adults entered PSH. We also estimated that PSH was associated with decreases in ED use, acute care hospitalizations, and days spent in residential SUD care, as well as an increase in community mental health use in the first two years after PSH entry consistent with substitution of acute and emergency care for specialty care in outpatient settings. Proportional spending changes between the baseline period and year 3 mirror these changes.

The adults in our analyses who received PSH exhibited a high burden of mental illnesses and substance us disorders: nearly all had a diagnosed mental health disorder, and two-thirds had been diagnosed with a SUD. The prevalence of these conditions was higher than has been reported in federal estimates, which found that two-thirds of PSH recipients nationally had a mental health diagnosis and approximately 40% had a SUD.[61] Consistent with the high prevalence of these conditions, adults used inpatient and residential behavioral health services intensively prior to receiving PSH although use declined afterwards. In addition, housing and supportive services may have allowed PSH residents to better manage their chronic health conditions than had they remained unstably housed.[35] One recent study, though it had no comparison group, found increases in self-rated health status and improvements in limitations to physical and social activity after adults were placed into PSH.[62]

We observed marked increases in health care spending and use before adults entered PSH. These increases may reflect patterns of care that facilitate entry into, or that establish individuals' eligibility for, PSH (medical documentation of a disability is a prerequisite for PSH eligibility). These patterns are also consistent with research that found increased rates of emergency department and inpatient use increase immediately before and after homeless adults enter shelters.[63] To the extent homeless individuals become connected to housing providers as a result

of using care – whose costs may be borne by Medicaid – there may be an opportunity for Medicaid programs to proactively target homeless individuals who may be eligible for PSH before they incur costly care. Medicaid expansion has increased coverage of homeless individuals and created an even larger incentive for Medicaid programs to target homeless individuals prior to incidents that require expensive and complex care.[64]

This study had several limitations. First, we observed increases in Medicaid spending and utilization among PSH recipients prior to PSH entry but did not see similar trends in our comparison population. These patterns likely reflect the unique circumstances under which individuals are identified as eligible for PSH and underscore the difficulty of isolating effects of PSH from trends preceding PSH entry. To mitigate bias that could arise from these pre-PSH trends, we excluded the 6 months before PSH entry, when increases were most pronounced. However, our estimates remain susceptible to bias if changes in the comparison sample do not correctly control for trends that would have been expected in the long run – excluding the 6 months prior to PSH entry – had adults in our intervention sample not received PSH. This assumption, though supported by our analyses of trends prior to the excluded 6-month period, is untestable. Second, our comparison sample is selected because individuals used services indicative of either episodic or chronic homelessness. If individuals do become stably housed through a non-PSH method, this may bias our results towards the null. If individuals are chronically homeless for an unusually long period of time, this may bias our results away from the null. Third, approximately 49% of our treatment sample left PSH during the time in which they were included in the study period, and we do not know the housing status of these individuals after leaving PSH. If individuals are moving into other stable housing conditions, we would expect to see the long-terms reductions in acute health expenditures present in this study. Finally, our analysis is limited to a subset of 54 of 67

counties in Pennsylvania, and excludes most of the Philadelphia region, which may limit the generalizability of our findings. However, our study population is substantially larger and more geographically diverse than prior analyses of PSH.[35,39-41,45,57,65] Pennsylvania has the fifth-largest Medicaid program in the country, which enhances the potential external generalizability of our estimates.

Within our study period, PSH experienced the largest growth of all publicly-financed housing programs for homeless people in Pennsylvania, broadening the program's enrollment and underscoring its salience to policymakers.[34] We found reductions in spending associated with receiving PSH, and also found that adults, many of whom had pre-existing behavioral health disorders, increasingly received treatment for these conditions in outpatient as opposed to acute care settings after receiving PSH. To our knowledge, this is one of the first studies to examine health care expenditures and use three years after the start of PSH, and our findings suggest that states looking to use waivers to provide housing services to Medicaid enrollees may realize long-term savings that partially offset the higher costs of providing these services and shift care away from acute and emergency settings.

3.0 Racial Inequity among Facilitators and Barriers to Medication Treatment for Opioid Use Disorder

3.1 Background

Only one in five individuals with opioid use disorder (OUD) receive medication treatment with evidenced-based forms of treatment for OUD (MOUD), including buprenorphine, methadone or naltrexone.[66] People receiving treatment for their OUD with methadone and buprenorphine have lower risk of all-cause and overdose mortality.[67] The use of MOUD varies between individuals of different demographic groups, geographic communities, and health status.

Black and Hispanic patients are significantly less likely than white patients to initiate and continue MOUD.[68-70] In one study, Black patients with OUD had half the odds of white patients of using an opioid use treatment service; in another, Black patients were half as likely as white patients, and Hispanic patients two-thirds as likely, to have 1 year or more of MOUD retention, while Hispanic patients were two-thirds as likely as white patients to have 2 years or more of MOUD retention.[68,69] To date, racial disparities in MOUD treatment remain largely unexplained, although it appears that the disparity may be moderated by location.[71] Disparities have also been hypothesized to be due to differences in criminal justice involvement, risk of housing instability, racial discrimination by providers, and other factors not directly related to clinical need.[72]

Involvement in a variety of human services systems and criminal justice systems, as well as use of health care services, may inhibit or support efforts to initiate patients to or retain patients in MOUD, and a variety of clinical diagnoses, including mental health disorders, HIV, and HCV, have also shown evidence of being related to variation in MOUD initiation and retention.[73-78]

Almost all of these social and clinical risk factors have shown evidence of racial disparities, which may mediate or moderate the relationship between race and MOUD initiation and retention.[79-81] For example, criminal justice system involvement may inhibit initiation and retention in MOUD. Known racial differences in criminal justice system involvement due to racial bias in arrest and incarceration rates may explain some of these racial differences.[80,81] Even in cases in which there are no racial disparities, there may still be differential effects by race given known racial biases in some of these systems.

Research on the factors associated with racial and ethnic disparities in MOUD treatment can be advanced by increased availability of linked health and human services and other data systems. Some state and local governments have invested in collecting and linking administrative data systems from publicly administered health, human services and criminal justice systems to inform operational and policy decisions on the opioid crisis and other public health problems. Using comprehensive, linked data from one such source from a large county in western Pennsylvania, this study examines whether the relationship between race and 1) initiation of MOUD and 2) retention in MOUD is changed by contact with health and human services and criminal justice systems. We focus on Medicaid enrollees because of the important role Medicaid plays in financing treatment for OUD, especially in states that have expanded Medicaid under the Affordable Care Act.

3.2 Methods

3.2.1 Data

We used data from the Allegheny County Department of Human Services Data Warehouse from January 1, 2014 to December 31, 2018. Demographic data on enrollees, including race, age, gender, and type of Medicaid eligibility were also obtained from the Data Warehouse (Appendix).The Data Warehouse links client-level data from several of the county's own programs, including two courts and the Allegheny County Jail (ACJ), and from other data sources, including Medicaid Managed Care Organizations. SAS 9.4 and Stata 15.1 were used for all data management and statistical analyses.[14,15]

3.2.2 Study Cohort

For the analysis of *initiation* of MOUD treatment, our sample included Allegheny County residents ages 18-64.5 years who were diagnosed with OUD between April 1, 2014 and October 1, 2017, with no recorded diagnosis of OUD in the prior three months. The analysis is limited to those enrollees with 180 days of Medicaid enrollment in the 180 days following the index OUD diagnosis, as well as fewer than 30 days in the Allegheny County Jail, to ensure that MOUD initiation could be measured during this period (we conducted a sensitivity analysis that did not include this limitation). For the analysis of *retention* in MOUD treatment, our sample included Allegheny County residents ages 18-64.5 years who initiated MOUD between January 1, 2015 and July 1, 2017. Enrollees were required to have one or more OUD diagnoses in the preceding year in addition to the enrollment limitations listed above.

Enrollees in the cohort were classified as either "white" or "Racial/Ethnic Minority" based on the race data available in the Allegheny County Data Warehouse. Enrollees whose race could not be identify were not included in the cohort. While it would have been preferable to separate the analysis into multiple racial and ethnic groups, the demographics of Allegheny County and sample size considerations precluded this option. Population estimates for Allegheny County in 2019 suggest that 80% of the population is white, 13.4% is Black, 4.1% Asian, and 2.2% are Hispanic or Latino.[82]

3.2.3 Outcomes

Among the *initiation* cohort, we examined the proportion of enrollees who initiated MOUD treatment in the 180 days after an index OUD diagnosis, categorized by race. MOUD included buprenorphine, methadone, and naltrexone, and was identified using a combination of physical health, behavioral health, and pharmacy claims to Medicaid and Allegheny County. Among the *retention* cohort, we examined the average proportion of days the enrollee had access to MOUD treatment (known as proportion of days covered, PDC) in the 180 days after starting MOUD, categorized by race. For MOUD prescriptions filled via outpatient pharmacy, we calculated PDC based on dispensing date and days supplied. If a prescription was refilled before the previous fill should have run out, use of the refill was assumed to begin the day after the end of the previous fill. For MOUD provided in clinical settings, the start and end date of the claim were used to identify the number of days covered by that claim.[83]

3.2.4 Potential Mediators and Moderators

We constructed variables based on a review of evidence on a) racial differences in the prevalence of health conditions and public service system contact, and b) the association between health status measures and public service system contact and our outcomes of interest (initiation in any MOUD and retention in MOUD). We identified three categories of potential mediators and moderators: health-related, criminal justice-related, and human services. Mediators and moderators were measured during the 180-day study period, as this is when they are most likely to impact initiation and retention during that period.

3.2.4.1 Health-Related Mediators and Moderators

Diagnoses of mental health conditions (including mood disorders, schizophrenia, and other psychotic disorders), Hepatitis-C (HCV), and Human Immunodeficiency Virus (HIV) were assessed using ICD-9 and ICD-10 diagnosis codes available in physical and behavioral health Medicaid claims, as well as county-funded behavioral health services claims.

Mental health diagnoses have been associated with greater odds of staying on MOUD longer than 1 year, as well as other successful OUD treatment effects. There is some research suggesting that buprenorphine may have antidepressant properties, and that referring patients with depression to MOUD treatment can itself improve depression symptoms.[84-86] Black patients are less likely than white patients to be diagnosed with psychiatric disorders in some settings despite little evidence that fewer Black than white patients actually have these disorders.[87]

A diagnosis of HCV has been shown to be negatively associated with MOUD continuation and remaining opioid abstinent.[69,88] Other infectious diseases, including HIV, may be a barrier to MOUD continuation because some antiretroviral treatment may interact with buprenorphine and

methadone, increasing the likelihood of symptoms of withdrawal.[89,90] Some studies, however, show no relationship between HIV and MOUD continuation, and others have shown a positive relationship.[73,75] Both HCV and HIV prevalence is higher among Black Americans than white Americans, and Hispanic Americans have a higher incidence of HIV.[91-93]

Emergency department (ED) visits and inpatient stays for non-OUD related reasons were identified using Medicaid claims, as well as county-funded behavioral health services claims. Emergency department visits and inpatient stays for non-OUD related reasons may interrupt individuals' ability to continue their medication treatment or be direct consequences of relapses and discontinuation of treatment. While even physicians who do not have waivers to prescribe buprenorphine and methadone for MOUD may dispense these medications in a hospital setting should a patient need them to relieve withdrawal symptoms, medications may only be dispensed for up to three days, and management of MOUD may be difficult if physicians are also helping patients manage acute pain for which opioids are indicated.[94,95] Additionally, survivors of opioid overdose receive MOUD extremely infrequently following the overdose, suggesting limited linkage between acute care settings and other opioid treatment providers.[96,97] A number of studies demonstrate racial disparities in ED and inpatient admission, length of stay, and treatment outcomes, some of which are attributed to between-hospital differences (Black and Hispanic patients going to hospitals with worse performance on these measures) and some of which are attributed to within-hospital performance (Black and Hispanic patients experience different care than white patients in the same hospital).[98-100]

We used physical and behavioral health Medicaid claims, as well as county-funded behavioral health services claims. to calculate a ratio of urine drug tests performed for every 100 outpatient visits/patient. The American Society of Addiction Medicine National Practice Guideline

for the Use of Medications in the Treatment of Addiction Involving Opioid Use note that there is a gap in the literature regarding the use of urine drug testing for MOUD, but do recommend frequently testing for buprenorphine and other substances. Frequent testing may improve provider confidence and encourage continued prescribing of MOUD, or it may undermine the patient-physician relationship. There is limited research on the racial disparity in urine drug testing related to MOUD, but evidence indicates that in opioid therapy for pain, Black patients are more likely to receive urine drug tests than white patients.[101,102]

3.2.4.2 Criminal Justice-Related Mediators and Moderators

We used booking and release dates to measure the number of days spent in the Allegheny County Jail. Time spent in jail or prison is a known barrier to receiving or continuing MOUD. Less than 5% of people referred to OUD treatment through the judicial system receive either methadone or buprenorphine/naloxone.[74] In addition, people who have been recently incarcerated are up to nearly 2.25 times more likely than those who have not to discontinue MOUD.[73,75,78] Qualitative research attributes this in part to the withdrawal experienced during incarceration.[76] In 2016, the jail incarceration rate for African Americans was 3.5 times that for non-Hispanic whites.[80]

We also counted the number of days of court appearances for both drug-related and non-drug offenses. Patients receiving daily methadone through a clinic may be forced to interrupt their treatment to be present in court. In an attempt to move from standard courts into drug courts, in which residents often do not incur jail time, people with OUD may interrupt, taper off, or never start MOUD, because judges in Allegheny County drug courts do not permit the use of MOUD.[103,104] In addition, Black and Hispanic Americans are more likely to be arrested for drug offenses than white Americans; some research suggests this may be due to racial bias in arrests.[105]

3.2.4.3 Human Services-Related Mediators and Moderators

We used a monthly marker of interaction with county child welfare and housing services to count the number of months of these interactions. Longer duration of MOUD is associated with greater odds of parents retaining custody of their children.[106] There is limited research on whether any interactions with the child welfare system as a barrier or facilitator to MOUD. We hypothesize that interactions with the child welfare system may facilitate MOUD continuation as people attempt to decrease their illicit opioid use and increase their likelihood of retaining custody of their children. On a national level, Black and Hispanic children are overrepresented in the child welfare system.[107]

People who are homeless are up to nearly 2.5 times more likely to discontinue MOUD than those who are not.[73,75,108] Black Americans make up a disproportionate share of those Americans who are homeless (40%).[109] Many housing programs or homeless shelters may require that residents not use any kind of opioids, including methadone and buprenorphine.[110] These kind of restrictions may pose a barrier to individuals continuing MOUD.

3.2.5 Controls

Gender and age at the index event were identified in enrollment data, and in the retention sample, any use of methadone for OUD treatment was identified using physical health and behavioral health claims, as well as county-funded behavioral health services claims. Use of methadone was included as a control in the retention analysis because there is some evidence of a racial difference in treatment preference.[111] Enrollees were classified as qualifying for Medicaid through an SSI, expansion, or other enrollment pathway, primarily composed of TANF and categorically needy enrollees.

3.2.6 Statistical Analysis

We described demographic characteristics of the cohort and used chi-square tests and t-tests to compare groups identified by race. Using a linear probability model for the initiation analysis and linear regression for the retention analysis, we regressed MOUD initiation and PDC on a binary race variable, as well as possible mediators and moderators of the relationship between MOUD initiation/retention and race, in 5 different sets of models. In **model 1**, we regressed initiation or retention on race alone. In **model 2**, we added the control variables to both analyses. In **models 3-1 through 3-11**, we regressed initiation or PDC on race, control variables, and one of the possible mediators (univariable analysis). In **model 4**, we regressed initiation or PDC on all possible mediators, including control variables. And in **model 5**, we added interaction terms between the possible mediators and race. We report coefficients, bootstrapped 95% confidence intervals, and p-values for the coefficients. A sensitivity analysis was run on the initiation model to ensure the results were robust to other model specifications.

Mediation analysis typically implies a causal relationship between the independent and dependent variables, which is not appropriate in this analysis; i.e. race is not a cause of initiation or retention of MOUD. We use mediation methods in this analysis to understand how much the possible mediators and moderators explain the relationship between race and outcomes. The direct effect is the coefficient of the race variable in the model. The indirect effect is the coefficient of the mediator variable multiplied by the coefficient of the race variable in **model 3**. The total effect is the sum of the direct and indirect effects, as well as the coefficient of race in **model 2**, and the proportion of the total effect that goes through the indirect effect is simply the indirect effect divided by the total effect.[112]

A standard causal mediation model would only include mediators with which the exposure and the outcome have a significant association. However, as this is not a causal mediation analysis and potential mediators are somewhat correlated (Appendix), we have chosen to include all of them in models 3, 4, and 5 to get the most complete picture of how use of these services is associated with changes in the relationship between race and MOUD initiation and retention.

3.3 Results

3.3.1 Descriptive Analysis

Among 6,067 enrollees who met study criteria for the MOUD initiation analysis, 18.7% were racial/ethnic minority (Table 3.1). Enrollees were majority male (53.1%) and predominantly between the ages of 30 and 39 (33.8%); however, racial/ethnic minority enrollees were much older on average (35.2% ages 50-64). Initiation of MOUD differed significantly between racial groups, with 28.3% of the racial/ethnic minority group initiating MOUD within 180 days of an index OUD diagnosis compared to 43.0% of white enrollees (p=.000).

Among 4,009 enrollees who met the study criteria for the MOUD retention analysis, 13.2% were racial/ethnic minorities. Age and gender breakdowns are similar to the initiation analysis. Racial/ethnic minority enrollees had an average PDC of 43.3% compared to an average PDC of 47.5% for white enrollees. In both cohorts, racial/ethnic minority enrollees were more likely than non-Hispanic white enrollees to be enrolled in Medicaid through an SSI pathway and less likely through an expansion pathway.

Racial/ethnic minority enrollees spent fewer days in Allegheny County courts for both drug and non-drug related charges, and spent more days in the ED and in inpatient settings. Racial/ethnic minority enrollees also had more months, on average, of public housing support than their non-Hispanic white counterparts.

Table 3.1: Cohort Demographics

	Initiation Cohort							Retention						
	Total		Racial/Ethnic Minority		White		p-value	Total		Racial/Ethnic Minority		White		p-value
	n or mean	% or SD	n or mean	% or SD	n or mean	% or SD		n or mean	% or SD	n or mean	% or SD	n or mean	% or SD	
Size of Groups	6,067	100	1137	18.7%	4,930	81.3%	-	4,009	100	529	13.2%	3,480	86.8%	-
Outcome														
Patient received MOUD within 180 days of OUD diagnosis (n, %)	2,442	40.3	322	28.3	2,120	43.0	0.000 *	-	-	-	-	-	-	-
Proportion of Days Covered by MOUD (Mean, SD)	-	-	-	-	-	-	-	0.47	0.35	0.43	0.33	0.48	0.35	0.009 *
Days of MOUD in 180 Days after Starting (Mean, SD)	-	-	-	-	-	-	-	84.5	62.9	77.9	60.2	85.5	63.3	0.009 *
Controls														
Gender (n, %)														
Female	2,845	46.9	451	39.7	2,394	48.6	0.000 *	1,920	47.9	214	40.5	1,706	49	0.000 *
Male	3,222	53.1	686	60.3	2,536	51.4		2,089	52.1	315	59.5	1,774	51	
Age Group (n, %)														
18-29	1,719	28.3	230	20.2	1,489	30.2	0.000 *	1,157	28.9	97	18.3	1,060	30.5	0.000 *
30-39	2,048	33.8	254	22.3	1,794	36.4		1,485	37	123	23.3	1,362	39.1	
40-49	1,096	18.1	253	22.3	843	17.1		696	17.4	123	23.3	573	16.5	
50-64	1,204	19.8	400	35.2	804	16.3		671	16.7	186	35.2	485	13.9	
Eligibility Group (n, %)														
Expansion	2,204	36.3	319	28.1	1,885	38.2	0.000 *	2,250	56.1	253	47.8	1,997	57.4	0.000 *
SSI	1,656	27.3	464	40.8	1,192	24.2		935	23.3	199	37.6	736	21.1	
Other	2,207	36.4	354	31.1	1,853	37.6		824	20.6	77	14.6	747	21.5	
Any Methadone Use (n, %)	-	-	-	-	-	-	-	1454.0	36.3	206.0	38.9	1248.0	35.9	0.170
Potential Mediators and Moderators in 180 days post-Index Date														
Mental Health Diagnosis (n, %)	2,119	34.9	402	35.4	1,717	34.8	0.736	1,323	33	150	28.4	1,173	33.7	0.015 *
HIV Diagnosis (n, %)	8	0.1	4	0.4	4	0.1	0.023 *	8	0.2	3	0.6	5	0.1	0.042 *
HCV Diagnosis (n, %)	317	5.2	44	3.9	273	5.5	0.023 *	262	6.5	30	5.7	232	6.7	0.388
Days in Allegheny County Jail (Mean, SD)	0.93	3.83	1.00	3.97	0.91	3.80	0.507	0.87	3.79	0.95	3.92	0.85	3.77	0.594
Days in Court, Drug Offenses (Mean, SD)	0.10	0.35	0.07	0.29	0.11	0.36	0.001 *	0.12	0.38	0.08	0.32	0.12	0.38	0.006 *
Days in Court, Nondrug Offenses (Mean, SD)	0.17	0.47	0.14	0.42	0.18	0.48	0.022 *	0.20	0.51	0.14	0.44	0.21	0.52	0.002 *
Months with Child Welfare Interaction (Mean, SD)	0.29	1.18	0.33	1.27	0.28	1.15	0.136	0.32	1.26	0.33	1.27	0.32	1.25	0.967
Months with Housing Support (Mean, SD)	0.40	1.40	0.92	2.03	0.28	1.17	0.000 *	0.39	1.40	0.73	1.89	0.34	1.30	0.000 *
Days in Inpatient Setting (Mean, SD)	0.78	4.01	1.10	5.38	0.71	3.61	0.003 *	0.69	3.44	1.10	4.52	0.63	3.24	0.004 *
Days in ED (Mean, SD)	1.35	2.79	1.81	3.96	1.25	2.43	0.000 *	1.05	1.95	1.29	2.37	1.02	1.88	0.003 *
Urine Drug Test Screening Ratio per 100 OP Visits (Mean, SD)	-	-	-	-	-	-	-	0.66	1.59	0.61	1.45	0.66	1.62	0.427

3.3.2 MOUD Initiation

3.3.2.1 Models 1-3

Race/ethnicity is a significant predictor of the likelihood of initiating MOUD, with racial/ethnic minority enrollees 15% less likely to initiate MOUD, and 12% less likely after gender, age, and Medicaid eligibility controls are added to the model (Table 3.2, Models A1 and A2). In univariable models that include controls + one mediator each (Table 3.3), race remains significant ($p<.01$ for all models); being a racial/ethnic minority is associated with a 11.2%-11.7% decrease in the likelihood of initiating MOUD in the 180 days following the index OUD diagnosis. Having a mental health diagnosis is associated with an increased likelihood of initiating MOUD (.033, $p<.01$). Spending a greater number of days in the Allegheny County Jail (-.005, $p<.01$) or more days in the ED (-.010, $p<.01$) were associated with a lower likelihood of initiating MOUD.

3.3.2.2 Model 4

Model A4 (Table 3.2, Figure 3.1) included all possible mediators in a linear probability model. With all other included mediators, being a racial/ethnic minority is associated with a 10.4% decreased likelihood of initiating MOUD ($p<.01$). A mental health diagnosis (.046, $p<.01$) was associated with an increased likelihood of initiating MOUD. Each day in the Allegheny County Jail (-.005, $p<.01$) and each day with a visit to the ED (-0.010, $p<.01$) were associated with a lower likelihood of initiating MOUD. The total indirect effect, describing how much of the relationship between race and MOUD initiation is adjusted by these mediators, is -.026, or 10.9% (95% CI 5.3% - 16.4%) of the total effect of race (.117).

3.3.2.3 Model 5

Model A5 (Table 3.2) includes all possible mediators, as well as these mediators interacted with the racial/ethnic minority variable.[112] Race remains a significant predictor of MOUD initiation (-.103, $p<.01$). All mediators that were significant in model A4 remain statistically significant in model A5. No interaction terms are significant. The point estimate of the total indirect effect in model A5 is similar to that in model A4 (-0.014), but is no longer statistically significantly different from 0. The proportion of the total effect made up of the indirect effect is also similar, but is not statistically different from zero (.121, $p>.05$). The lack of significance may be due to sample size limitations (Appendix).

Table 3.2: Initiation Models A1, A2, A4, A5

	(A1)	(A2)	(A4)	(A5)
	Race Only	Race + Controls	Multivariable Model	Multivariable w/ Interactions
Controls:				
Racial/Ethnic Minority (vs. White)	-0.147**	-0.117**	-0.104**	-0.103**
	(-0.178 - -0.116)	(-0.149 - -0.085)	(-0.136 - -0.073)	(-0.148 - -0.057)
Ages 30-39 (vs. 18-29)		0.006	0.003	0.004
		(-0.024 - 0.035)	(-0.026 - 0.033)	(-0.026 - 0.034)
Ages 40-49 (vs. 18-29)		0.003	0.000	0.000
		(-0.039 - 0.045)	(-0.042 - 0.042)	(-0.042 - 0.043)
Ages 50-64 (vs. 18-29)		-0.005	-0.009	-0.011
		(-0.045 - 0.036)	(-0.049 - 0.031)	(-0.050 - 0.028)
Male (vs. Female)		-0.013	-0.013	-0.013
		(-0.036 - 0.010)	(-0.036 - 0.010)	(-0.035 - 0.009)
SSI Medicaid eligibility		-0.156**	-0.157**	-0.157**
		(-0.187 - -0.124)	(-0.189 - -0.126)	(-0.188 - -0.126)
Expansion Medicaid eligibility		0.020	0.016	0.016
		(-0.009 - 0.048)	(-0.013 - 0.045)	(-0.013 - 0.045)
Possible Mediators:				
Mental Health Diagnosis			0.046**	0.048**
			(0.017 - 0.074)	(0.017 - 0.078)
HIV Diagnosis			-0.138	-0.036
			(-0.402 - 0.126)	(-0.537 - 0.464)
HCV Diagnosis			0.020	0.009
			(-0.029 - 0.070)	(-0.046 - 0.063)
Days in Allegheny County Jail			-0.005**	-0.005*
			(-0.009 - -0.002)	(-0.009 - -0.001)
Days in Court, Drug Offenses			0.007	-0.009
			(-0.045 - 0.058)	(-0.061 - 0.043)
Days in Court, Nondrug Offenses			0.001	0.009
			(-0.037 - 0.038)	(-0.031 - 0.049)
Months with Child Welfare Interaction			-0.003	0.000
			(-0.014 - 0.007)	(-0.012 - 0.012)
Months with Housing Support			-0.008	-0.005
			(-0.016 - 0.000)	(-0.016 - 0.007)
Days in Inpatient Setting			0.000	0.001
			(-0.003 - 0.004)	(-0.003 - 0.006)
Days in ED			-0.010**	-0.013**
			(-0.015 - -0.006)	(-0.019 - -0.008)
Racial/Ethnic Minority (vs. White) Interacted with…				
Mental Health Diagnosis				-0.005
				(-0.068 - 0.058)
HIV Diagnosis				-0.206
				(-0.732 - 0.321)

Table 3.2 Continued

HCV Diagnosis				0.081
				(-0.083 - 0.245)
Days in Allegheny County Jail				-0.003
				(-0.011 - 0.005)
Days in Court, Drug Offenses				0.096
				(-0.023 - 0.214)
Days in Court, Nondrug Offenses				-0.043
				(-0.128 - 0.042)
Months with Child Welfare Interaction				-0.017
				(-0.040 - 0.005)
Months with Housing Support				-0.008
				(-0.026 - 0.010)
Days in Inpatient Setting				-0.003
				(-0.009 - 0.004)
Days in ED				0.008
				(-0.001 - 0.017)
Constant	0.430**	0.465**	0.471**	0.473**
	(0.416 - 0.444)	(0.436 - 0.495)	(0.441 - 0.502)	(0.441 - 0.504)
Total Indirect Effect	-	-	-0.013**	-0.014
	-	-	(-0.019 - -0.007)	(-0.042 - .014)
Direct Effect	-	-0.117**	-0.104**	-0.103**
	-	(-0.149 - -0.085)	(-0.136 - -0.073)	(-0.148 - -0.057)
Total Effect	-	-0.117**	-0.117**	-0.117**
	-	(-0.149 - -0.085)	(-0.149 - -0.085)	(-0.149 - -0.085)
Proportion of Indirect to Total Effect	-	-	0.109**	.121
	-	-	(0.053 - 0.164)	(-0.124 - 0.366)
Observations	6,067	6,067	6,067	6,067
R-squared	0.014	0.037	0.044	0.045
R-squared Adj.	0.013	0.036	0.041	0.041

ci in parentheses

** p<0.01, * p<0.05

Table 3.3: Initiation Models A3-1 through A3-10

	A3-1	A3-2	A3-3	A3-4	A3-5	A3-6	A3-7	A3-8	A3-9	A3-10
	Mental Health Diagnosis	HIV Diagnosis	HCV Diagnosis	Days in Allegheny County Jail	Days in Court, Drug Offenses	Days in Court, Nondrug Offenses	Months with Child Welfare Interaction	Months with Housing Support	Days in Inpatient Setting	Days in ED
Racial/Ethnic Minority (vs. White)	-0.116**	-0.117**	-0.116**	-0.116**	-0.117**	-0.117**	-0.116**	-0.112**	-0.117**	-0.112**
	(-0.148 - -0.0843)	(-0.148 - -0.0850)	(-0.148 - -0.0847)	(-0.148 - -0.0842)	(-0.149 - -0.0854)	(-0.149 - -0.0854)	(-0.148 - -0.0846)	(-0.144 - -0.0810)	(-0.148 - -0.0850)	(-0.144 - -0.0807)
Mediator	0.0329*	-0.158	0.0204	-0.0053**	-0.0056	-0.0122	-0.0048	-0.0078	-0.0013	-0.0095**
	(0.00616 - 0.0596)	(-0.423 - 0.107)	(-0.0291 - 0.0699)	(-0.00829 - -0.00245)	(-0.0431 - 0.0319)	(-0.0378 - 0.0135)	(-0.0152 - 0.00573)	(-0.0157 - 7.90e-05)	(-0.00435 - 0.00180)	(-0.0134 - -0.00572)
Ages 30-39 (vs. 18-29)	0.0040	0.0058	0.0057	0.0057	0.0056	0.0052	0.0061	0.0066	0.0056	0.0048
	(-0.0257 - 0.0337)	(-0.0240 - 0.0355)	(-0.0240 - 0.0353)	(-0.0241 - 0.0355)	(-0.0241 - 0.0353)	(-0.0246 - 0.0351)	(-0.0236 - 0.0359)	(-0.0231 - 0.0362)	(-0.0240 - 0.0353)	(-0.0249 - 0.0344)
Ages 40-49 (vs. 18-29)	0.0011	0.0032	0.0029	0.0006	0.0026	0.0016	0.0023	0.0037	0.0033	0.0043
	(-0.0406 - 0.0427)	(-0.0384 - 0.0448)	(-0.0387 - 0.0445)	(-0.0411 - 0.0422)	(-0.0391 - 0.0443)	(-0.0404 - 0.0437)	(-0.0394 - 0.0440)	(-0.0380 - 0.0454)	(-0.0386 - 0.0451)	(-0.0373 - 0.0460)
Ages 50-64 (vs. 18-29)	-0.00471	-0.00419	-0.0057	-0.00888	-0.00534	-0.00674	-0.00608	-0.00305	-0.00422	-0.00634
	(-0.0450 - 0.0356)	(-0.0445 - 0.0361)	(-0.0458 - 0.0344)	(-0.0491 - 0.0313)	(-0.0452 - 0.0345)	(-0.0474 - 0.0340)	(-0.0462 - 0.0340)	(-0.0434 - 0.0373)	(-0.0446 - 0.0362)	(-0.0463 - 0.0336)
Male (vs. Female)	-0.0124	-0.0132	-0.0132	-0.0099	-0.0129	-0.0126	-0.0138	-0.0150	-0.0132	-0.0138
	(-0.0355 - 0.0108)	(-0.0361 - 0.00978)	(-0.0362 - 0.00981)	(-0.0331 - 0.0133)	(-0.0359 - 0.0101)	(-0.0357 - 0.0106)	(-0.0367 - 0.00906)	(-0.0381 - 0.00810)	(-0.0363 - 0.00983)	(-0.0365 - 0.00893)
SSI Medicaid eligibility (vs. Other)	-0.161**	-0.156**	-0.156**	-0.155**	-0.156**	-0.156**	-0.156**	-0.155**	-0.155**	-0.151**
	(-0.193 - -0.129)	(-0.187 - -0.124)	(-0.187 - -0.124)	(-0.186 - -0.124)	(-0.187 - -0.125)	(-0.187 - -0.125)	(-0.188 - -0.125)	(-0.186 - -0.124)	(-0.186 - -0.124)	(-0.183 - -0.120)
Expansion Medicaid eligibility (vs. Other)	0.0209	0.0197	0.0198	0.0208	0.0199	0.0196	0.0187	0.0184	0.0197	0.0162
	(-0.00770 - 0.0495)	(-0.00897 - 0.0483)	(-0.00882 - 0.0483)	(-0.00779 - 0.0495)	(-0.00872 - 0.0484)	(-0.00915 - 0.0483)	(-0.0102 - 0.0477)	(-0.0103 - 0.0472)	(-0.00896 - 0.0483)	(-0.0124 - 0.0449)
Constant	0.455**	0.465**	0.464**	0.469**	0.466**	0.468**	0.468**	0.468**	0.466**	0.478**
	(0.426 - 0.484)	(0.436 - 0.495)	(0.435 - 0.494)	(0.439 - 0.499)	(0.436 - 0.496)	(0.438 - 0.498)	(0.438 - 0.497)	(0.438 - 0.498)	(0.436 - 0.495)	(0.448 - 0.508)
Observations	6,067	6,067	6,067	6,067	6,067	6,067	6,067	6,067	6,067	6,067
R-squared	0.038	0.037	0.037	0.038	0.037	0.037	0.037	0.037	0.037	0.039
Indirect Effect	-0.001	0.000	-0.001	-0.001	0.000	0.000	-0.001	-0.005	0.000	-0.005
p-value of Indirect Effect	0.317	0.517	0.429	0.155	0.771	0.602	0.406	0.0597	0.556	0.000
Total Effect	-0.117	-0.117	-0.117	-0.117	-0.117	-0.117	-0.117	-0.117	-0.117	-0.117
Proportion of Total Effect	0.444	0.23	0.43	0.884	-0.12	-0.107	0.572	3.968	0.195	3.927
p-value of Proportion	0.340	0.516	0.431	0.159	0.772	0.602	0.406	0.058	0.552	0.000

ci in parentheses

** p<0.01, * p<0.05

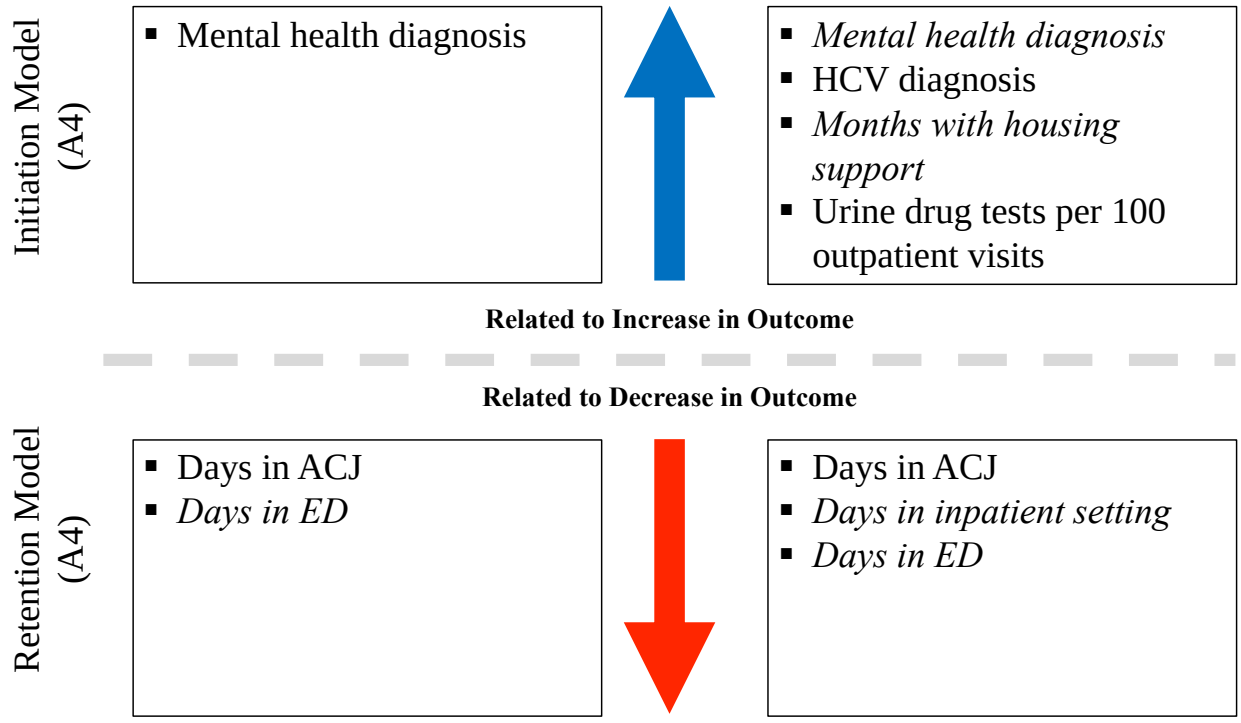

Figure 3.1: Direction of Covariates in Models A4 and A5

Mediators with differences by race are italicized, indicating that variation in race may be explained by that variable.

3.3.2.4 Sensitivity Analyses

We conducted a sensitivity analysis (data not shown) to test the robustness of the linear probability results to a logistic specification. We calculated predictive margins for race in 4 of the 5 models (A1, A2, A4, A5) and found that difference between predictive margins was nearly identical to the race coefficient in each model.

We also conducted a sensitivity analysis in the initiation cohort (data not shown) that eliminated the requirement that enrollees spend a maximum of 30 days in ACJ. This increased the size of the cohort from 6,067 to 6,669; racial/ethnic minority enrollees spent an average of 13.31 days in ACJ vs. 7.87 for non-Hispanic white enrollees ($p<.01$, up from means between 0.9 and 1.0 in the primary sample). In this cohort, the effect of a single ACJ day decreased (from .005 to .002). Unlike in the primary model, there was a very small significant interaction effect between ACJ days and race (.001, $p<.01$), indicating that the association between ACJ days and initiation of MOUD was stronger for racial/ethnic minority enrollees.

3.3.3 MOUD Retention

3.3.3.1 Models 1-3

Non-white versus non-Hispanic white race/ethnicity was a significant predictor of the proportion of days retained in MOUD in the 180 days following the index date, with racial/ethnic minority enrollees having 3.6% fewer days (6.5 days) of MOUD than white enrollees even after gender, age, and use of methadone controls are added to the model (Table 3.4, Models B1 and B2). This is the total race effect. In univariable models that included controls + one mediator each (Table 3.5), race remained significant for 9 of 11 models; being a racial/ethnic minority was associated with a 3.43%-3.85% decrease in PDC. A mental health diagnosis (.039, $p<.01$), each

month of housing support (.008, p<.05), and a higher ratio of urine drug tests to 100 outpatient visits (.038, p<.05) was associated with an increase in PDC. Each day in the Allegheny County Jail (-.008, p<.01), each day spent in court for drug (-.038, p<.01) or non-drug offenses (-.029, p<.01), and each additional day in an inpatient (-.005, p<.01) or ED setting (-.015, p<.01) were associated with decreases in PDC. Even when statistically significant, the effect sizes were small enough that the proportion of the indirect effects to total effects are never statistically significantly different from 0, suggesting that these account for negligible variation by race.

3.3.3.2 Model 4

Model B4 (Table 3.4, Figure 3.1) included all possible mediators. In this model, being a racial/ethnic minority was no longer statistically significantly associated with PDC (47.3% vs 44.4%, a 2.9% decrease, p<.10). Having a mental health diagnosis (.04, p<.01) or HCV diagnosis (.04, p<.05), months with public housing support (.01,p <.05), and the ratio of urine drug screens to 100 outpatient visits (.04, p<.01) were associated with an increase in PDC. Days in the Allegheny County Jail (-.007, p<.01), and days spent in inpatient (-.003, p<.05) and ED settings (-.014, p<.01) were associated with a decrease in PDC. The total indirect effect, describing how much of the relationship between race and MOUD retention is adjusted by these mediators, was 18.8% of the total race effect (-0.029), but not statistically significantly different from 0%, possibly due to sample size limitations (Appendix).

3.3.3.3 Model 5

Model A5 (Table 3.5) includes all possible mediators, as well as these mediators interacted with the racial/ethnic minority variable.[112] In this model, race remained an insignificant predictor of MOUD initiation (.03, p>.05). While coefficients of main effects in model A5 remained similar

to those in A4, several were no longer statistically significant, including HCV diagnosis and days in an inpatient setting. No interaction terms were significant. The total indirect effect remains qualitatively similar to that in Model A4 (-.005, $p>.05$), and the proportion of the total effect comprised of the indirect effect is not statistically different from zero.

Table 3.4: Retention Models B1, B2, B4, B5

	(B1)	(B2)	(B4)	(B5)
	Race Only	Race + Controls	Multivariable Model	Multivariable w/ Interactions
Controls:				
Racial/Ethnic Minority (vs. White)	-0.042*	-0.036*	-0.029	-0.031
	(-0.077 - -0.008)	(-0.069 - -0.003)	(-0.063 - 0.005)	(-0.082 - 0.020)
Ages 30-39 (vs. 18-29)		0.026	0.019	0.019
		(-0.001 - 0.053)	(-0.007 - 0.045)	(-0.006 - 0.045)
Ages 40-49 (vs. 18-29)		0.041**	0.033*	0.032*
		(0.014 - 0.068)	(0.007 - 0.059)	(0.007 - 0.058)
Ages 50-64 (vs. 18-29)		0.071**	0.058**	0.056**
		(0.034 - 0.107)	(0.024 - 0.093)	(0.022 - 0.091)
Male (vs. Female)		-0.033**	-0.029**	-0.029**
		(-0.053 - -0.014)	(-0.048 - -0.009)	(-0.047 - -0.010)
Any Methadone Use		-0.311**	-0.280**	-0.280**
		(-0.332 - -0.290)	(-0.301 - -0.259)	(-0.301 - -0.260)
SSI Medicaid eligibility		-0.057**	-0.047**	-0.046**
		(-0.088 - -0.026)	(-0.077 - -0.017)	(-0.076 - -0.015)
Expansion Medicaid eligibility		-0.018	-0.003	-0.002
		(-0.043 - 0.008)	(-0.029 - 0.023)	(-0.029 - 0.024)
Possible Mediators:				
Mental Health Diagnosis			0.040**	0.037**
			(0.020 - 0.060)	(0.016 - 0.059)
HIV Diagnosis			0.005	0.003
			(-0.183 - 0.192)	(-0.278 - 0.285)
HCV Diagnosis			0.037*	0.032
			(0.001 - 0.074)	(-0.006 - 0.070)
Days in Allegheny County Jail			-0.007**	-0.007**
			(-0.009 - -0.005)	(-0.009 - -0.005)
Days in Court, Drug Offenses			-0.016	-0.019
			(-0.050 - 0.019)	(-0.053 - 0.016)
Days in Court, Nondrug Offenses			-0.006	-0.007
			(-0.030 - 0.018)	(-0.033 - 0.018)
Months with Child Welfare Interaction			0.001	0.002
			(-0.006 - 0.008)	(-0.006 - 0.010)
Months with Housing Support			0.008*	0.008
			(0.000 - 0.015)	(-0.000 - 0.016)
Days in Inpatient Setting			-0.003*	-0.003
			(-0.006 - -0.000)	(-0.006 - 0.000)

Table 3.4 Continued

Days in ED			-0.014**	-0.013**
			(-0.020 - -0.008)	(-0.019 - -0.006)
Urine Drug Test per 100 outpatient Visits			0.036**	0.036**
			(0.029 - 0.043)	(0.029 - 0.044)
Racial/Ethnic Minority (vs. White) Interacted with…				
Mental Health Diagnosis				0.026
				(-0.044 - 0.095)
HIV Diagnosis				-0.027
				(-0.461 - 0.407)
HCV Diagnosis				0.052
				(-0.059 - 0.162)
Days in Allegheny County Jail				0.003
				(-0.004 - 0.010)
Days in Court, Drug Offenses				0.038
				(-0.063 - 0.140)
Days in Court, Nondrug Offenses				0.004
				(-0.067 - 0.076)
Months with Child Welfare Interaction				-0.010
				(-0.040 - 0.019)
Months with Housing Support				-0.001
				(-0.017 - 0.014)
Days in Inpatient Setting				0.001
				(-0.006 - 0.008)
Days in ED				-0.008
				(-0.021 - 0.004)
Urine Drug Test per 100 Outpatient Visits				-0.002
				(-0.030 - 0.026)
Constant	0.475**	0.599**	0.562**	0.563**
	(0.463 - 0.487)	(0.569 - 0.629)	(0.531 - 0.594)	(0.533 - 0.593)
Total Indirect Effect	-	-	-0.007	-0.005
	-	-	(-0.014 - 0.001)	(-0.038 - 0.029)
Direct Effect	-	-	-0.029	-0.031
	-	-	(-0.063 - 0.005)	(-0.082 - 0.020)
Total Effect	-	-0.029	-0.029	-0.029
	-	(-0.063 - 0.005)	(-0.063 - 0.005)	(-0.063 - 0.005)
Proportion of Indirect to Total Effect	-	-	0.188	0.131
	-	-	(-0.079 - 0.456)	(-0.821 - 1.083)
Observations	4,009	4,009	4,009	4,009
R-squared	0.002	0.189	0.235	0.236

Table 3.4 Continued

R-squared Adj.	0.001	0.188	0.231	0.230

ci in parentheses

** p<0.01, * p<0.05

Table 3.5: Retention Models B3-1 through B3-14

	B3-1	B3-2	B3-3	B3-4	B3-5	B3-6	B3-7	B3-8	B3-9	B3-10	B3-11
	Mental Health Diagnosis	HIV Diagnosis	HCV Diagnosis	Days in Allegheny County Jail	Days in Court, Drug Offenses	Days in Court, Nondrug Offenses	Months with Child Welfare Interaction	Months with Housing Support	Days in Inpatient Setting	Days in ED	Urine Drug Test Screening Ratio per 100 OP Visits
Racial/Ethnic Minority	-0.0327	-0.0359*	-0.0355*	-0.0343*	-0.0369*	-0.0370*	-0.0358*	-0.0385*	-0.0347*	-0.0329	-0.0347*
(vs. White)	(-0.0662 - 0.000793)	(-0.0694 - -0.00244)	(-0.0689 - -0.00220)	(-0.0680 - -0.000668)	(-0.0705 - -0.00319)	(-0.0705 - -0.00351)	(-0.0693 - -0.00238)	(-0.0721 - -0.00487)	(-0.0681 - -0.00125)	(-0.0663 - 0.000426)	(-0.0680 - -0.00146)
Mediator	0.0394**	-0.007	0.0206	-0.00759**	-0.0383**	-0.0289**	-0.001	0.00761*	-0.00520**	-0.0150**	0.0377**
	(0.0191 - 0.0598)	(-0.212 - 0.199)	(-0.0156 - 0.0567)	(-0.00972 - -0.00545)	(-0.0647 - -0.0120)	(-0.0467 - -0.0112)	(-0.00838 - 0.00672)	(0.000611 - 0.0146)	(-0.00793 - -0.00248)	(-0.0208 - -0.00929)	(0.0307 - 0.0448)
Ages 30-39 (vs. 18-29)	0.0246	0.0264	0.0266	0.0261	0.0245	0.0239	0.0264	0.0258	0.0264	0.0250	0.0241
	(-0.00218 - 0.0514)	(-0.000540 - 0.0533)	(-0.000375 - 0.0536)	(-0.00101 - 0.0532)	(-0.00251 - 0.0516)	(-0.00310 - 0.0509)	(-0.000536 - 0.0534)	(-0.00112 - 0.0528)	(-0.000774 - 0.0535)	(-0.00166 - 0.0517)	(-0.00244 - 0.0507)
Ages 40-49 (vs. 18-29)	0.0380**	0.0410**	0.0410**	0.0380**	0.0375**	0.0371**	0.0409**	0.0404**	0.0416**	0.0422**	0.0403**
	(0.0107 - 0.0654)	(0.0137 - 0.0684)	(0.0136 - 0.0685)	(0.0108 - 0.0652)	(0.0104 - 0.0647)	(0.00997 - 0.0641)	(0.0135 - 0.0683)	(0.0131 - 0.0677)	(0.0144 - 0.0688)	(0.0152 - 0.0693)	(0.0134 - 0.0671)
Ages 50-64 (vs. 18-29)	0.0686**	0.0705**	0.0701**	0.0670**	0.0662**	0.0652**	0.0702**	0.0686**	0.0736**	0.0698**	0.0672**
	(0.0322 - 0.105)	(0.0338 - 0.107)	(0.0334 - 0.107)	(0.0307 - 0.103)	(0.0297 - 0.103)	(0.0290 - 0.101)	(0.0337 - 0.107)	(0.0320 - 0.105)	(0.0366 - 0.111)	(0.0335 - 0.106)	(0.0312 - 0.103)
Male (vs. Female)	-0.0307**	-0.0333**	-0.0332**	-0.0298**	-0.0330**	-0.0327**	-0.0335**	-0.0312**	-0.0345**	-0.0359**	-0.0341**
	(-0.0504 - -0.0111)	(-0.0529 - -0.0137)	(-0.0528 - -0.0135)	(-0.0496 - -0.0101)	(-0.0527 - -0.0133)	(-0.0524 - -0.0131)	(-0.0532 - -0.0137)	(-0.0505 - -0.0120)	(-0.0540 - -0.0151)	(-0.0551 - -0.0166)	(-0.0539 - -0.0142)
SSI Medicaid eligibility	-0.309**	-0.311**	-0.311**	-0.310**	-0.310**	-0.310**	-0.311**	-0.312**	-0.311**	-0.311**	-0.283**
(vs. Other)	(-0.330 - -0.288)	(-0.332 - -0.290)	(-0.332 - -0.290)	(-0.331 - -0.289)	(-0.331 - -0.289)	(-0.331 - -0.289)	(-0.332 - -0.290)	(-0.333 - -0.291)	(-0.332 - -0.289)	(-0.332 - -0.290)	(-0.304 - -0.261)
Expansion Medicaid	-0.0642**	-0.0567**	-0.0575**	-0.0561**	-0.0560**	-0.0567**	-0.0569**	-0.0568**	-0.0538**	-0.0486**	-0.0480**
eligibility (vs. Other)	(-0.0951 - -0.0333)	(-0.0876 - -0.0258)	(-0.0883 - -0.0266)	(-0.0869 - -0.0254)	(-0.0869 - -0.0251)	(-0.0876 - -0.0259)	(-0.0877 - -0.0261)	(-0.0876 - -0.0260)	(-0.0845 - -0.0231)	(-0.0793 - -0.0179)	(-0.0789 - -0.0171)
Any Methadone Use	-0.0190	-0.0177	-0.0183	-0.0134	-0.0155	-0.0164	-0.0179	-0.0159	-0.0184	-0.0153	-0.0090
	(-0.0443 - 0.00629)	(-0.0430 - 0.00762)	(-0.0437 - 0.00708)	(-0.0392 - 0.0125)	(-0.0404 - 0.00952)	(-0.0418 - 0.00901)	(-0.0434 - 0.00752)	(-0.0413 - 0.00948)	(-0.0435 - 0.00672)	(-0.0406 - 0.0100)	(-0.0348 - 0.0168)
Constant	0.587**	0.599**	0.598**	0.602**	0.604**	0.606**	0.600**	0.595**	0.602**	0.613**	0.559**
	(0.557 - 0.618)	(0.569 - 0.629)	(0.568 - 0.628)	(0.572 - 0.631)	(0.574 - 0.634)	(0.577 - 0.635)	(0.570 - 0.629)	(0.565 - 0.625)	(0.572 - 0.632)	(0.583 - 0.642)	(0.528 - 0.589)
Observations	4,009	4,009	4,009	4,009	4,009	4,009	4,009	4,009	4,009	4,009	4,009
R-squared	0.192	0.189	0.189	0.196	0.191	0.191	0.189	0.19	0.192	0.196	0.217
Indirect Effect	-0.003	0.000	0.000	-0.002	0.001	0.001	0.000	0.003	-0.001	-0.003	-0.001
p-value of Indirect Effect	0.003	0.950	0.379	0.249	0.180	0.133	0.829	0.073	0.261	0.098	0.653
Total Effect	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036	-0.036
Proportion of Total Effect	9.012	0.060	1.051	4.441	-2.624	-3.068	0.257	-7.192	3.511	8.358	3.321
p-value of Proportion	0.084	0.950	0.405	0.324	0.211	0.206	0.831	0.164	0.316	0.182	0.653

ci in parentheses

** p<0.01, * p<0.05

3.4 Discussion

In Allegheny County, there is a 12% gap between white and racial/ethnic minority Medicaid enrollees in the initiation of MOUD, and a nearly 4% gap in PDC – approximately one week. Both the initiation and retention gaps were smaller than estimates in previous research, but differences are still notable.[68-70] Using administrative data from the Allegheny Department of Human Services, we were able to explain approximately 10% of the variability by race in initiation of MOUD and 18% in retention, although the 18% explained was not significantly different from zero.

Not all covariates that contributed to variation in the levels of initiation and retention will have explained variation due to race. For example, similar to other studies, mental health diagnoses were related to increased initiation and retention in MOUD.[84-87] In addition to buprenorphine possibly having antidepressant effects, individuals with recorded mental health diagnoses may be engaging in care at a higher rate than other individuals, which may facilitate both the initiation and retention of MOUD. Mental health diagnoses are not associated with race in the initiation cohort, so while the presence of a mental health diagnosis may increase retention in MOUD, it is likely not explaining variation in MOUD initiation related to race. However, there *is* a difference in the rate of mental health diagnoses in the retention cohort, so the presence of a diagnosis may explain some of the variation related to race in that model.

Our findings underscore the need to focus on two settings to improve initiation and coordination of MOUD – acute care facilities and jails and prisons. Each day in ACJ was associated with decreased initiation of and retention in MOUD. While the effect sizes appear small

(.5% decreased likelihood of initiation for each day), individuals in the top 5% of the distribution of days spent in ACJ may see a 3.5% decrease in likelihood of initiation associated with jailtime alone. Even though MOUD in correctional settings reduces illicit opioid use post-release, as of 2016, ACJ, like most jails and prisons across the country, did not offer MOUD.[110,113,114] More recently, many jails and prisons, including some in Rhode Island, Vermont, and Massachusetts, are beginning to implement the use of MOUD in these settings, with support from organizations like the National Sheriffs' Association, the American Correctional Association, and the National Governor's Association, among others.[115] In the main initiation and retention models, there is no relationship between race and days spent in ACJ, suggesting that days in ACJ is likely not contributing to the variation by race. However, a sensitivity analysis on the initiation model that loosened the restriction on the number of days in ACJ did see a large difference by race, indicating that the slightly smaller effect size may be related to racial disparities in MOUD initiation. In addition, the impact of each ACJ day is very slightly moderated by race in that model. As the jail incarceration rate for African Americans was 3.5 times that for non-Hispanic whites, providing access to MOUD in jail and prison settings – and reexamining racial bias in arrests – may be important intervention points for limiting racial disparities in MOUD initiation and retention.[80]

Decreases in initiation and retention associated with time spent in acute care settings, whether an inpatient or ED setting, for non-OUD diagnoses, may be a proxy for severe OUD, or may demonstrate a lack of coordination between these settings and patients' other providers.[96,97] These settings may be great opportunities to initiate treatment: a randomized trial of individuals with opioid-positive urine tests found that individuals given buprenorphine in the ED had a higher rate of treatment engagement two months later compared to those who only received a referral to

treatment.[116] Warm handoffs between the ED or inpatient and outpatient providers may also alleviate barriers for the patient.[117]

This study had several limitations. First, the data used in this study are specific to Allegheny County and results may not be generalizable to other states. Second, our analysis relies on administrative data available to Allegheny County during the study period. We cannot account for any additional care received by enrollees that was not financed by Medicaid or Allegheny County. Third, there are many factors unrelated to MOUD that may impact initiation and retention in MOUD, and some of these may be associated with otherwise unexplained variation by race. We are unable to measure factors like patient and provider preferences and attitudes or within-provider variation, and we are also unable to measure how the impact of region-level barriers to care varies across racial groups.[110]

Factors unrelated to the need for MOUD may impact initiation to and retention in MOUD, and may be associated with otherwise unexplained variation by race. Using linked administrative data from publicly administered health, human services and criminal justice systems allowed us to explain between 10% and 20% of the variation related to race, but the large majority of this variation continues to go unexplained. Future research in this space should explore the patient experience of initiating and continuing MOUD (including patient preferences), the physician-patient relationship and interactions related to MOUD, implicit bias among clinicians, patients, and within other public systems. Clinicians who prescribe MOUD should be aware of these facilitators and barriers in working with patients. And policymakers can potentially close the initiation and retention clinical disparities by providing support in social services settings.

Appendix A Model Selection

Nagin writes that "the objective of the model selection is not the maximization of some statistic of model fit. Rather it is to summarize the distinctive features of the data in as parsimonious a fashion as possible."[18] In this case, the goal of model was to identify unique joint trajectories of ambulatory care visits and ED visits among Medicaid enrollees in the first 12 months of expansion enrollment. We looked to identify a model that had the best characteristics based on BIC and substantive usefulness that met all of Nagin's criteria (Appendix Table 2).

We assessed group based multi-trajectory models with a minimum of 4 groups and a maximum of 6 groups. A 4-group model was selected as the minimum because there were at least 4 trajectories that needed to be represented in the final model. A 6-group model was selected as the maximum for parsimony.

The six-group model has the highest BIC; this would be our selection if we were focused solely on BIC.

Appendix Table 1: BIC of Trajectory Models

Number of groups	BIC, participants	BIC, observations
4	-8,232,931.90	-8,233,024.06
5	-8,174,593.34	-8,174,706.16
6	-8,141,598.05	-8,141,731.53

It was also important to identify a model that would contain potential trajectories of use identified when ambulatory care and emergency department models were run separately. The six-group model was the only model to encompass these; as a result, the six-group model was chosen.

Appendix B Appendix Tables for "Emergency Department and Ambulatory Care Visits in the First 12 Months of Coverage Under Medicaid Expansion: A Group-Based Trajectory Analysis"

Appendix Table 2: Study Cohort Compared to Expansion Enrollees with No ED or Ambulatory Care Use

	Study Cohort		No ED or Ambulatory Care Use		Significance
TOTAL	601,877	81.1%	139,885	18.9%	-
Gender					
Female	341,185	56.7%	59,237	42.3%	0.000
Male	260,692	43.3%	80,648	57.7%	
Age					
19-34	305,213	50.7%	79,649	56.9%	0.000
35-54	234,662	39.0%	47,082	33.7%	
55-64	62,002	10.3%	13,154	9.4%	
Race					
Non-Hispanic White	346,949	57.6%	81,266	58.1%	0.000
Non-Hispanic Black	142,313	23.6%	32,727	23.4%	
Hispanic	64,982	10.8%	11,238	8.0%	
Other	47,633	7.9%	14,654	10.5%	
MCO Region					
Lehigh Capital	123,359	20.5%	28,128	20.1%	0.000
New East	85,353	14.2%	17,868	12.8%	
New West	43,172	7.2%	8,989	6.4%	
Southeast	218,039	36.2%	56,067	40.1%	
Southwest	131,954	21.9%	28,833	20.6%	
Urbanicity					
Rural	153,389	25.5%	31,269	22.4%	0.000
Urban	448,488	74.5%	108,616	77.6%	
Previous Enrollment					
Not previously enrolled	197,222	32.8%	66,964	47.9%	0.000
Previously enrolled	404,655	67.2%	72,921	52.1%	

Appendix Table 3: Nagin's Diagnostic Criteria for Group-Based Trajectory Model

Group	Model Estimate of Group Probability (95% CI)[a]	Proportion Classified in Group[b]	Average Posterior Probability[c]	Odds Correct Classification[d]
Group #1	0.290 (0.287, 0.294)	0.300	0.79	8.98
Group #2	0.215 (0.212, 0.218)	0.223	0.79	14.00
Group #3	0.212 (0.208, 0.215)	0.200	0.75	10.96
Group #4	0.175 (0.172, 0.177)	0.175	0.81	20.40
Group #5	0.057 (0.056, 0.058)	0.052	0.82	75.11
Group #6	0.051 (0.050, 0.052)	0.050	0.90	174.61

[a] 95% confidence intervals (CIs) should be narrow.
[b] Proportion classified in group based on maximum posterior probability rule. The values of the proportion classified in the group should be similar to the model estimates of group probabilities in the second column.
[c] Average posterior probability obtained by averaging the posterior probabilities for all individuals placed in each group by the maximum posterior probability rule. Acceptable values are 0.7 or greater.
[d] Acceptable values are 5.0 or greater for all groups.

Appendix C Linking HMIS data and Medicaid claims

HMIS is a software system for tracking the provision of federally funded housing services administered by local housing agencies. Any program that has obtained Continuum of Care funding from the Department of Housing and Urban Development (HUD) to "quickly rehouse individuals and families" must participate in a HMIS software system. We obtained HMIS data from the Pennsylvania Department of Economic and Community Development (DCED) and the Allegheny County Department of Human Services (ACDHS) that includes any provision of PSH during the years 2007-2016. Our dataset consists of 54 of Pennsylvania's 67 counties. While available HMIS data does not include several larger metropolitan areas like Philadelphia and Erie, it does include the Pittsburgh metropolitan area, as well as Allentown, State College, and Altoona, and more rural areas than have been included in many other PSH studies.

PSH HMIS and Pennsylvania Medicaid data were matched by the Pennsylvania Department of Human Services (DHS) on social security number (SSN) and date of birth (allowing for partial matches based on full SSN matches and last four digits of SSN plus date of birth), previously described as yielding highly accurate matches.[55] This method was validated by comparing the first four characters of the first name in both datasets, yielding at least 76 percent validation among both datasets.[118]

Both DCED and ACDHS have data quality plans that set a standard of completeness rate at 90% (DCED) or 95% (ACDHS), and both strive for 100% compliance with complete data entry.[119,120]

Appendix D Developing the Treatment and Comparison Cohorts

Of adult Medicaid recipients entering PSH over this period, 96% received PSH for at least 180 days, consistent with the program's intent of providing non-time limited housing assistance to its recipients.

When we set out to develop the treatment and comparison cohorts, we originally attempted to match trends in spending in the twelve months prior to PSH entry. However, among PSH enrollees, we found marked increases in Medicaid spending in the 6 months preceding PSH entry that were not replicable among potential comparison enrollees. We interpret this marked increase to be unique to the PSH cohort and reflective of events facilitating entry into PSH. Thus, the conventional approach of matching a comparison population with similar pre-intervention trends would have led to an inflated estimate of savings. To address this issue, we selected a comparison sample of Medicaid enrollees whose trends in behavioral health, physical health, and pharmacy spending most closely resembled those of PSH recipients in the 7 to 15 months prior to PSH entry (the period immediately preceding the marked increase in spending for the PSH group).

We required individuals in both the treatment and comparison cohorts to meet minimum Medicaid enrollment criteria in three of the time periods depicted in Appendix Table 4. Individuals were required to have at least 6 months of enrollment in the year following PSH entry, as well as 6 months in the 7 to 15 months prior to PSH entry, to permit sufficient enrollment time to examine individual-level changes in Medicaid spending and utilization before and after PSH entry while retaining individuals with some gaps in their Medicaid coverage. We also required at least 4 months of enrollment during the pre-baseline period, 16-28 months prior to PSH entry, to allow us to assess diagnosis of chronic conditions prior to the baseline, which allowed us to adjust for

these conditions during our analysis of baseline utilization and spending. See Appendix F for more details on this adjustment.

Appendix Table 4: Study Periods

Name of Period	Months Relative to PSH	Enrollment Requirement
Pre-Baseline	16-28 months before PSH entry	Any 4 months, at least 15 days each
Baseline	7-15 months before PSH entry	Any 6 months, at least 15 days each
Pre-Treatment	1-6 months before PSH entry	-
Year 1	0-11 months after PSH entry	Any 6 months, at least 15 days each
Year 2	12-23 months after PSH entry	-
Year 3	24-35 months after PSH entry	-

Appendix E Matching Process

We identified a comparison sample of Medicaid enrollees with similar demographic and health characteristics as PSH recipients who did not receive PSH, but who received other housing services indicative of episodic or chronic homelessness. These housing services included emergency shelters, transitional housing, day shelters, and other non-shelter homelessness services. None of the comparison enrollees received PSH during the study period.

We identified the comparison sample in two stages. The first stage is described in full in the main portion of this paper. In the second phase, we matched PSH enrollees to comparison enrollee start dates on the following characteristics: age, chronic condition diagnoses during the baseline period as measured by the Chronic Illness & Disability Payment System (CDPS) and MedicaidRx (MRX), and trends in Medicaid spending for behavioral health care, physical health care, and outpatient pharmacy spending.[23] To assess trends, we used a linear regression model to measure the impact of time relative to the index date on spending, controlling for seasonal effects.

For each PSH recipient, we selected up to 4 comparison enrollee-start date combinations in which the spending trends in the previous 7-15 months most closely resembled trends among PSH recipients 7-15 months prior to PSH entry. All four matched enrollee-start dates for one treatment individual were from unique enrollees. Matched enrollee-start dates were replaced in the sample and were eligible to be matched a second time. As a result, the PSH cohort has 1,226 enrollees. The comparison cohort has 970 unique enrollees who are included in the sample 1,204 times. Individual comparison enrollees only matched to up to 6 PSH enrollees. While enrollee-start dates were replaced in the sample, none were matched to a PSH individual more than once.

Appendix F Spending and Utilization Measures

For person-months included in the study period, all spending was included in the "total spending" category as well as an additional spending category as described below in Appendix Table 2. Categories are mutually exclusive; once a fee-for-service claim or MCO encounter was assigned to one spending category, it could not be assigned to another. Categories in Appendix Table 2 are listed in order of assignment. In addition to "total spending," we created two additional composite spending categories: behavioral health spending, which included case management, community behavioral health, residential behavioral health, and inpatient behavioral health; and physical health spending, which included dental, ED, non-behavioral health inpatient, primary care, other physician services, other ambulatory care, and other services spending. Pharmacy spending, which may include spending on both behavioral and physical health diagnoses, was not included in either composite category.

Spending and utilization analyses were adjusted for gender, race/ethnicity, age at the index date, Medicaid managed care region of the state (known as HealthChoices region), and whether or not the individual resided in Allegheny County. In addition, adjustments were made for chronic condition diagnoses in the year *prior* to the year being examined in the analysis. For example, for all months in year 2, chronic condition flags were turned on if the individual was diagnosed with the chronic condition during year 1. This allowed us to make adjustments for health status that might impact spending and utilization without including health status characteristics that are endogenous with increased spending and health services use.

To limit the influence of high-cost outliers, we top-coded each spending variable to the 99th percentile, and each utilization variable to the 99.9th percentile, of the distribution of monthly per-person spending for that variable.

Appendix Table 5: Spending Measures

Spending category:	**Includes spending associated with:**	**Aggregated spending category:**
Dental	Claims in the dental file and claims submitted by dental providers in the outpatient and professional files.	Physical health
Pharmacy	Claims in the pharmacy file	Pharmacy
Emergency department	Claim lines for emergency department visits that were not immediately followed by an inpatient admission to a short-stay acute care hospital or resulted in death, as well as claims with the same claim number	Physical health
Case management	Claims with procedure code "T1017" or provider type 21, "Case Manager"[121]	Behavioral health
Community behavioral health	Claims associated with outpatient visits made to a provider or clinic with a behavioral health type or specialty, or for a behavioral health service	Behavioral health
Residential behavioral health	Claims associated with admissions to a residential treatment facility for a behavioral health diagnosis, or to a specialty behavioral health residential treatment facility	Behavioral health
Inpatient behavioral health	Claims associated with admissions to an acute care facility for a behavioral health related diagnosis group, or to a specialty behavioral health inpatient facility	Behavioral health
Non-behavioral health inpatient	Inpatient claims not associated with behavioral health admissions	Physical health
Primary care	Claims associated with outpatient visits made to a provider or clinic with a primary care specialty	Physical health
Other physician services	Outpatient and professional claims with provider type 31, "Physician"[121]	Physical health

Appendix Table 5 Continued

Other ambulatory care	Unclassified outpatient claims, professional claims with office/clinic place of service	Physical health
Other services	Lab and radiology claims, and other services not previously categorized in our hierarchy, including transportation, physical therapy, and speech therapy (7% of total Medicaid spending for sample during study period)	Physical health

Utilization measures are listed in Appendix Table 3. As noted, all utilization measures are measure per 100 person-months to ease of interpretation.

Appendix Table 6: Utilization Measures

Utilization Measure:	**Definition:**
Inpatient Non-Behavioral Health	A count of the number of all-cause inpatient hospitalizations at short-stay acute care hospitals (excluding psychiatric hospitals and units) per 100 person-months.
Inpatient Mental Health Visits	A count of the number of days in an acute care facility for a mental health related diagnosis group, or to a specialty behavioral health inpatient facility, per 100 person-months.
Inpatient – SUD	A count of the number of days in an acute care facility for substance use related diagnosis group, or to a specialty SUD inpatient facility, per 100 person-months.
Dental Visits	A count of the number of visits to a provider or clinic with a dental provider type and a dental procedure code, or for a dental service provided by an FQHC, per 100 person-months.
Primary Care Visits	A count of the number of outpatient visits made to a provider or clinic with a primary care specialty, per 100 person-months.
Community Mental Health Visits	A count of the number of outpatient visits made to a provider or clinic with a mental health type or specialty, or for a mental health service, per 100 person-months.
Community SUD Visits	A count of the number of outpatient visits made to a provider or clinic with a substance use disorder type or specialty, or for a substance use service, per 100 person-months.
Residential Mental Health Visits	A count of the number of days associated with admissions to a residential treatment facility for a mental health diagnosis, or to a specialty mental health residential treatment facility.

Appendix Table 6 Continued

Residential SUD Visits	A count of the number of days associated with admissions to a residential treatment facility for a SUD diagnosis, or to a specialty SUD residential treatment facility.
Emergency Department Visits	A count of emergency department visits that were not immediately followed by an inpatient admission to a short-stay acute care hospital or resulted in death, per 100 person-months.
Emergent ED Visits	A count of ED visits classified as "emergent" by the NYU algorithm, per 100 person months.
Nonemergent ED Visits	A count of ED visits classified as "nonemergent" by the NYU algorithm, per 100 person months.
Psychiatric ED Visits	A count of ED visits classified as a mental health visit by the NYU algorithm, per 100 person months.
Substance Use Disorder ED Visits	A count of ED visits classified as a substance use disorder visit by the NYU algorithm, per 100 person months.
Injury ED Visits	A count of ED visits classified as an injury by the NYU algorithm, per 100 person months.
Antipsychotic & Antidepressant Prescription Utilization	A count of the total days supplied of antipsychotic and antidepressant prescriptions filled by enrollees, per 100 person-months.

Appendix G Propensity Score Matching

Appendix Table 7: Propensity Score Matching Phase I

	Treatment Group Coefficient	Confidence Interval
Male	-0.14*	(-0.27 - -0.02)
Non-Hispanic Black	-0.35*	(-0.49 - -0.20)
Hispanic	-0.21	(-0.59 - 0.16)
Other	-0.09	(-0.57 - 0.40)
Ever Dually Enrolled	-0.39*	(-0.63 - -0.15)
Ever Enrolled as Disabled	0.33*	(0.20 - 0.46)
New East	0.28	(-0.10 - 0.65)
New West	0.84*	(0.52 - 1.15)
Southeast	-0.93*	(-1.47 - -0.39)
Southwest	-0.16	(-0.45 - 0.13)
Allegheny County	0.91*	(0.65 - 1.17)
Urban	-0.05	(-0.30 - 0.19)
HCV diagnosis	0.43	(-1.93 - 2.78)
HIV diagnosis	1.13	(-0.97 - 3.23)
SUD diagnosis	0.29	(-1.07 - 1.66)
HCV # SUD	0.60	(-0.19 - 1.39)
HIV # SUD	-0.18	(-1.06 - 0.70)
Mental health diagnosis (MH)	1.98*	(1.35 - 2.62)
HCV # MH	-0.98	(-3.30 - 1.35)
HIV # MH	-0.61	(-2.76 - 1.54)
Tobacco use disorder (TUD)	0.14	(-0.53 - 0.81)
Cardiovascular, extra low (CDPS)	0.89	(-0.05 - 1.82)
Gastrointestinal, low (CDPS)	0.29	(-0.42 - 1.00)
Infectious disease, low (CDPS)	-1.46	(-3.73 - 0.81)
Diabetes (MRX)	-0.20	(-1.21 - 0.82)
Cardiac (MRX)	0.30	(-0.64 - 1.24)
TUD # SUD	0.36	(-1.06 - 1.79)
Cardiovascular # SUD	-0.87	(-2.32 - 0.59)
Gastrointestinal # SUD	0.79	(-0.36 - 1.94)
Infectious # SUD	0.17	(-2.42 - 2.76)
Diabetes # SUD	-0.17	(-2.01 - 1.67)
Cardiac # SUD	0.34	(-1.11 - 1.80)
TUD # MH	-0.07	(-0.77 - 0.64)
Cardiovascular # MH	-0.65	(-1.63 - 0.32)

Appendix Table 7 Continued

Gastrointestinal # MH	-0.29	(-1.03 - 0.46)
Infectious # MH	1.55	(-0.74 - 3.84)
Diabetes # MH	0.58	(-0.47 - 1.62)
Cardiac # MH	-0.13	(-1.10 - 0.85)
SUD # MH	-0.42	(-1.84 - 0.99)
TUD # SUD # MH	0.03	(-1.44 - 1.51)
Cardiovascular # SUD # MH	0.84	(-0.66 - 2.33)
Gastrointestinal # SUD # MH	-0.66	(-1.84 - 0.52)
Infectious # SUD # MH	-0.07	(-2.65 - 2.52)
Diabetes # SUD # MH	-0.17	(-2.04 - 1.71)
Cardiac # SUD # MH	-0.53	(-2.02 - 0.96)
Constant	-5.02*	(-5.69 - -4.36)

* $p<0.05$

Appendix Table 8: Propensity Score Matching Phase II

	Treatment Group Coefficient	Confidence Interval
Male	0.07	(-0.05 - 0.20)
Age at index date	-0.01*	(-0.01 - -0.00)
Ever Dually Enrolled	0.56*	(0.33 - 0.80)
Ever Enrolled as Disabled	-0.09	(-0.22 - 0.04)
New East	0.09	(-0.26 - 0.45)
New West	-0.09	(-0.38 - 0.20)
Southeast	-0.30	(-0.83 - 0.24)
Southwest	-0.02	(-0.30 - 0.25)
Allegheny County	-0.12	(-0.37 - 0.13)
Urban	-0.06	(-0.29 - 0.17)
HIV diagnosis	0.11	(-0.59 - 0.81)
Ever tobacco use disorder (TUD)	-0.01	(-0.68 - 0.66)
Ever cardiovascular, extra low (CDPS)	0.34	(-0.69 - 1.37)
Ever gastrointestinal, low (CDPS)	0.16	(-0.56 - 0.89)
Ever infectious disease, low (CDPS)	-0.91	(-3.22 - 1.40)
Ever diabetes (MRX)	0.01	(-1.01 - 1.03)
Ever cardiac (MRX)	0.49	(-0.56 - 1.53)
Ever mental health diagnosis	-0.11	(-0.75 - 0.53)
Ever SUD diagnosis	-0.20	(-1.63 - 1.22)
Baseline psychosis/Bipolar/ Depression (MRX)	-0.82*	(-0.96 - -0.69)
Baseline cardiac (MRX)	-1.29*	(-1.47 - -1.12)
Baseline substance abuse, low (CDPS)	-0.75*	(-0.94 - -0.56)
Baseline Psychiatric, medium low (CDPS)	-0.66*	(-0.85 - -0.47)
Baseline Pulmonary, low (CDPS)	-0.57*	(-0.78 - -0.35)
Baseline Infectious, low (CDPS)	-0.20	(-0.46 - 0.07)
Baseline Cardiovascular, extra low (CDPS)	-1.07*	(-1.32 - -0.82)
Baseline Gastro, low (CDPS)	-0.66*	(-0.90 - -0.42)
Baseline Diabetes (MRX)	-0.32*	(-0.63 - -0.01)
Baseline Psychiatric, medium (CDPS)	-0.92*	(-1.19 - -0.65)
Ever HIV # Ever SUD	0.20	(-0.63 - 1.02)
Ever HCV ## Ever SUD	0.24	(-0.07 - 0.55)
Ever TUD ## Ever SUD	-0.06	(-1.51 - 1.38)
Ever cardiovascular # Ever SUD	-0.11	(-1.52 - 1.31)
Ever gastrointestinal # Ever SUD	0.01	(-1.23 - 1.25)
Ever infectious # Ever SUD	0.18	(-2.50 - 2.86)
Ever diabetes # Ever SUD	0.17	(-1.70 - 2.05)
Ever cardiac # Ever SUD	0.45	(-0.98 - 1.87)
Ever TUD # Ever MH	-0.04	(-0.74 - 0.67)
Ever cardiovascular # Ever MH	-0.09	(-1.15 - 0.98)
Ever gastrointestinal # Ever MH	0.06	(-0.69 - 0.82)
Ever infectious # Ever MH	1.18	(-1.15 - 3.51)

Appendix Table 8 Continued

Ever diabetes ## Ever MH	0.36	(-0.68 - 1.40)
Ever cardiac # Ever MH	0.25	(-0.83 - 1.33)
1.ever_sud# Ever MH	0.19	(-1.28 - 1.67)
Ever TUD # Ever SUD # Ever MH	0.42	(-1.07 - 1.91)
Ever cardiovascular # Ever SUD # Ever MH	0.03	(-1.41 - 1.48)
Ever gastrointestinal # Ever SUD # Ever MH	0.02	(-1.25 - 1.29)
Ever infectious # Ever SUD # Ever MH	-0.35	(-3.03 - 2.32)
Ever diabetes ## Ever SUD # Ever MH	-0.43	(-2.33 - 1.48)
Ever cardiac # Ever SUD # Ever MH	-0.31	(-1.77 - 1.15)
Count of other CDPS-MRx Flags	-0.81*	(-0.93 - -0.70)
Behavioral health spending trend	0.00*	(0.00 - 0.00)
Physical health spending trend	-0.00	(-0.00 - 0.00)
Pharmcy spending trend	0.00	(-0.00 - 0.00)
Constant	-4.14*	(-4.83 - -3.46)

* $p<0.05$

Appendix H : Spending and Utilization Full Results

For spending outcomes, we estimated differential changes between the PSH and comparison cohorts over time using a two-part regression model: a probit model to account for person-months with no spending and a generalized linear model with a log link and gamma variance function for months in which individuals incurred >$0 in spending. For utilization measures, we used linear models.We re-estimated linear models for count-denominated outcomes using two-part regression models with a probit model and a generalized linear model with a log link and poisson variance function, and obtained estimates of relative changes that were qualitatively similar to those of our main analyses.

We adjusted for age, gender, race/ethnicity, urbanicity, county, and time-varying chronic health conditions. Standard errors were clustered at the person level to account for correlation between months within individuals. We report adjusted differential changes in per member per month spending or utilization between the PSH and matched comparison samples from baseline (7-15 months prior to PSH entry) through the first, second, and third year following PSH entry.

Appendix Table 9: Relative changes in spending from baseline, Part 1

	Baseline per Person-Month (Quarters -5 to -3)			Year 0 Difference from Baseline (Quarters 0 to +3)			
	PSH Cohort	Comp. Cohort	Difference	PSH Cohort	Comp. Cohort	Difference (Bootstrapped 95% CI)	p-value
Total	$1,228.19	$956.71	$271.48	-$43.72	$0.57	-$44.29 (-$154.30, $64.90)	0.430
Behav. Health	$511.85	$336.69	$175.16	-$38.34	-$4.67	-$33.68 (-$92.90, $24.89)	0.318
Phys. Health	$415.36	$347.02	$68.34	-$30.42	$22.94	-$53.35 (-$101.60, -$5.71)	0.017
Dental	$7.30	$6.56	$0.73	$0.18	-$0.62	$0.79 (-$0.78, $2.36)	0.390
Pharmacy	$169.44	$143.07	$26.37	$40.94	$17.18	$23.76 ($4.58, $42.69)	0.002
ED	$51.14	$45.76	$5.38	-$6.97	-$0.06	-$6.91 (-$13.16, -$0.60)	0.044
Case Mngmt.	$51.50	$27.69	$23.81	$58.74	-$1.74	$60.48 ($49.62, $71.56)	0.000
Comm. BH	$199.14	$116.03	$83.11	$47.99	$24.35	$23.64 (-$2.15, $49.47)	0.066
Res. BH	$111.80	$72.49	$39.31	-$91.62	$2.57	-$94.19 (-$121.40, -$67.34)	0.000
IP BH	$63.16	$52.90	$10.25	-$37.07	-$18.63	-$18.44 (-$36.54, -$0.45)	0.073
IP Non-BH	$188.66	$117.79	$70.86	-$49.13	$4.19	-$53.32 (-$92.49, -$14.05)	0.015
Primary Care	$16.63	$13.51	$3.12	$1.61	$1.71	-$0.10 (-$2.27, $2.07)	0.921
Other Phys.	$30.35	$27.41	$2.94	$1.06	-$2.26	$3.32 (-$3.35, $3.36)	0.056
Other Amb. Care	$28.48	$24.59	$3.89	$0.81	$0.85	-$0.04 (-$2.27, $2.07)	0.970
Other	$57.19	$64.06	-$6.87	$2.66	$4.74	-$2.08 (-$13.84, $9.86)	0.684

Appendix Table 10: Relative changes in spending from baseline, Part 2

	Year 1 Difference from Baseline (Quarters +4 to +7)				Year 2 Difference from Baseline (Quarters +8 to +11)			
	PSH Cohort	Comp. Cohort	Difference (Bootstrapped 95% CI)	p-value	PSH Cohort	Comp. Cohort	Difference (Bootstrapped 95% CI)	p-value
Total	-$71.41	-$0.66	-$70.74 (-$192.00, $46.21)	0.244	-$72.53	$72.92	-$145.45 (-$288.80, -$3.37)	0.046
Behav. Health	-$72.01	-$7.62	-$64.38 (-$130.10, $1.45)	0.055	-$118.34	$0.59	-$118.93 (-$190.50, -$47.79)	0.001
Phys. Health	-$46.71	$0.87	-$47.59 (-$98.27, $2.73)	0.065	-$23.58	$49.11	-$72.69 (-$132.80, -$13.23)	0.017
Dental	-$0.73	-$0.13	-$0.61 (-$2.27, $1.10)	0.481	-$0.72	$0.15	-$0.87 (-$2.74, $0.99)	0.359
Pharmacy	$52.50	$21.26	$31.24 ($7.39, $54.39)	0.009	$66.12	$33.79	$32.34 ($1.03, $64.71)	0.047
ED	-$9.74	-$3.83	-$5.90 (-$12.44, $0.71)	0.078	-$12.56	-$4.26	-$8.30 (-$16.04, -$0.83)	0.032
Case Mngmt.	$38.32	-$0.03	$38.35 ($26.19, $50.40)	0.000	$26.44	$6.04	$20.40 ($7.07, $33.93)	0.003
Comm. BH	$4.85	$18.35	-$13.49 (-$40.99, $13.41)	0.331	-$16.23	$23.35	-$39.58 (-$71.51, -$8.00)	0.015
Res. BH	-$75.52	$0.97	-$76.50 (-$106.40, -$45.80)	0.000	-$78.43	-$13.83	-$64.61 (-$95.33, -$33.63)	0.000
IP BH	-$23.81	-$18.33	-$5.48 (-$23.86, $13.42)	0.564	-$31.72	-$15.18	-$16.54 (-$36.07, $3.67)	0.103
IP Non-BH	-$53.09	$5.70	-$58.79 (-$100.20, -$16.67)	0.006	-$53.99	$35.21	-$89.20 (-$139.40, -$38.57)	0.001
Primary Care	-$0.15	$1.44	-$1.60 (-$4.01, $0.79)	0.193	$0.33	$0.41	-$0.09 (-$2.78, $2.60)	0.950
Other Phys.	-$2.34	-$1.19	-$1.15 (-$5.71, $1.69)	0.542	-$1.32	$0.97	-$2.30 (-$7.32, $0.87)	0.272
Other Amb. Care	-$2.38	-$0.34	-$2.04 (-$4.01, $0.79)	0.096	-$2.25	$0.96	-$3.21 (-$2.78, $2.60)	0.019
Other	$6.96	-$4.84	$11.80 (-$2.83, $26.04)	0.109	$7.83	-$2.44	$10.27 (-$5.72, $26.38)	0.210

Appendix Table 11: Relative changes in utilization from baseline, Part 1

	Baseline per Person-Month (Quarters -5 to -3)			Year 0 Difference from Baseline (Quarters 0 to +3)			
	PSH Cohort	Comp. Cohort	Difference	PSH Cohort	Comp. Cohort	Difference (95% CI)	p-value
ED	23.59	21.56	2.03	-3.57	0.14	-3.72 (-6.94, -0.49)	0.020
ED: Emerg.	5.30	6.28	-0.98	-0.78	1.13	-1.91 (-3.42, -0.40)	0.010
ED: Nonemerg.	8.06	11.24	-3.17	-0.44	0.48	-0.92 (-2.82, 0.97)	0.340
ED: Injury	4.04	4.85	-0.81	-0.91	0.02	-0.93 (-2.06, 0.19)	0.100
ED: Psych.	1.42	1.47	-0.05	-0.78	-0.05	-0.73 (-1.38, -0.08)	0.030
ED: SUD	1.38	1.05	0.32	-0.37	-0.31	-0.06 (-0.62, 0.50)	0.840
ED: Unclass.	3.12	3.75	-0.63	-0.26	0.71	-0.98 (-2.05, 0.10)	0.080
AC Hosp.	3.77	2.50	1.27	-1.27	-0.04	-1.23 (-1.96, -0.50)	0.000
Prim. Care	27.10	24.60	2.50	1.71	1.25	0.46 (-3.14, 4.05)	0.800
Days of Anti-Depress.	1291.54	1032.62	258.92	117.95	36.03	81.92 (-51.92, 215.77)	0.230
Days of Anti-Psych.	540.45	452.41	88.04	113.77	23.10	90.68 (7.97, 173.39)	0.030
Comm. MH	184.13	107.20	76.93	84.90	-2.06	86.96 (66.12, 107.81)	0.000
Comm SUD	93.23	61.82	31.41	34.03	31.52	2.51 (-25.02, 30.04)	0.860
Res. MH	0.20	3.31	-3.11	-0.30	-2.91	2.61 (-0.87, 6.09)	0.140
Res. SUD	38.47	20.80	17.67	-33.19	6.62	-39.81 (-51.86, -27.76)	0.000
IP MH	2.79	2.22	0.57	-1.80	-0.55	-1.25 (-2.02, -0.49)	0.000
IP SUD	0.10	0.09	0.01	-0.04	-0.06	0.03 (-0.08, 0.13)	0.610
Dental	6.91	6.17	0.74	0.26	-0.50	0.76 (-0.66, 2.18)	0.290

Appendix Table 12: Relative changes in utilization from baseline, Part 2

	Year 1 Difference from Baseline (Quarters +4 to +7)				Year 2 Difference from Baseline (Quarters +8 to +11)			
	PSH Cohort	Comp. Cohort	Difference (95% CI)	p-value	PSH Cohort	Comp. Cohort	Difference (95% CI)	p-value
ED	-5.41	-2.13	-3.28 (-6.52, -0.04)	0.050	-7.23	-2.57	-4.66 (-8.29, -1.04)	0.010
ED: Emerg.	-1.04	0.01	-1.05 (-2.50, 0.39)	0.150	-1.05	-0.54	-0.51 (-2.23, 1.22)	0.560
ED: Nonemerg.	-2.31	-1.28	-1.03 (-2.93, 0.87)	0.290	-3.05	-3.21	0.17 (-1.87, 2.20)	0.870
ED: Injury	-1.08	-0.81	-0.26 (-1.34, 0.82)	0.640	-1.63	-1.39	-0.24 (-1.45, 0.97)	0.690
ED: Psych.	-0.53	-0.15	-0.38 (-1.00, 0.25)	0.240	-0.72	0.24	-0.96 (-1.83, -0.10)	0.030
ED: SUD	-0.10	-0.19	0.09 (-0.47, 0.65)	0.760	-0.39	-0.18	-0.22 (-0.85, 0.41)	0.500
ED: Unclass.	-0.29	0.54	-0.83 (-2.06, 0.40)	0.180	-0.34	0.75	-1.09 (-2.43, 0.26)	0.110
AC Hosp.	-1.21	-0.41	-0.81 (-1.57, -0.05)	0.040	-1.45	0.15	-1.60 (-2.47, -0.73)	0.000
Prim. Care	-1.37	-0.46	-0.91 (-4.84, 3.02)	0.650	-0.07	-3.96	3.89 (-0.48, 8.25)	0.080
Days of Anti-Depress.	4.62	-36.01	40.62 (-114.05, 195.30)	0.610	-30.95	122.75	-153.69 (-335.62, 28.23)	0.100
Days of Anti-Psych.	95.85	-1.23	97.08 (-1.00, 195.15)	0.050	103.66	20.45	83.21 (-40.20, 206.63)	0.190
Comm. MH	46.72	1.59	45.13 (20.66, 69.60)	0.000	28.88	12.10	16.79 (-11.76, 45.33)	0.250
Comm SUD	-0.68	23.95	-24.63 (-55.45, 6.20)	0.120	-9.20	11.38	-20.58 (-56.74, 15.59)	0.260
Res. MH	0.51	4.12	-3.60 (-12.80, 5.60)	0.440	-0.33	-2.93	2.61 (-1.18, 6.40)	0.180
Res. SUD	-24.54	6.16	-30.71 (-45.93, -15.49)	0.000	-23.75	3.57	-27.32 (-42.44, -12.20)	0.000
IP MH	-1.12	-0.70	-0.43 (-1.23, 0.38)	0.300	-1.41	-0.61	-0.80 (-1.65, 0.05)	0.070
IP SUD	-0.08	-0.04	-0.03 (-0.13, 0.07)	0.550	-0.07	-0.04	-0.03 (-0.15, 0.09)	0.640
Dental	-0.73	-0.08	-0.66 (-2.20, 0.89)	0.410	-0.70	-0.25	-0.46 (-2.08, 1.17)	0.580

Appendix I Sensitivity Analysis

We conducted a sensitivity analysis that further omits the three months of the baseline period closest to PSH entry to avoid picking up any additional pre-enrollment increases in spending that might cause us to conflate long-run spending changes with regression to the mean effects.

Our adjusted difference-in-differences analysis compares the three years after PSH entry to a baseline period of 7 to 15 months prior to entry. This displays these year three results next to year three results for a sensitivity analysis that uses only 10 to 15 months prior to PSH entry as a baseline period. Almost all spending measures show similar changes in spending as compared to the original analysis. Overall physical health spending and community behavioral health spending no longer show statistical significance, but the coefficients are qualitatively similar as confidence intervals widen. There is a slight drop in the decrease in total spending, as well, suggesting these estimates are sensitive to the chosen baseline period.

Appendix Table 13: Sensitivity Analysis Results

	Baseline (Months -7 to -15)	Difference (Bootstrapped 95% CI)	p-value	Sensitivity Baseline (Months -10 to -15)	Difference (Bootstrapped 95% CI)	p-value
Total	$1,228.19	-$145.45 (-$288.80, -$3.37)	0.046	$1,151.52	-$91.66 (-$228.70, $47.41)	0.193
Behav. Health	$511.85	-$118.93 (-$190.50, -$47.79)	0.001	$462.82	-$85.27 (-$160.30, -$10.46)	0.026
Phys. Health	$415.36	-$72.69 (-$132.80, -$13.23)	0.017	$425.07	-$72.74 (-$145.40, $1.33)	0.052
Pharmacy	$169.44	$32.34 ($1.03, $64.71)	0.047	$177.84	$43.45 ($10.36, $75.67)	0.009
ED	$51.14	-$8.30 (-$16.04, -$0.83)	0.032	$51.99	-$9.12 (-$17.16, -$1.18)	0.025
Case Mngmt.	$51.50	$20.40 ($7.07, $33.93)	0.003	$49.88	$23.01 ($8.82, $37.36)	0.002
Comm. BH	$199.14	-$39.58 (-$71.51, -$8.00)	0.015	$190.88	-$30.92 (-$63.43, $1.59)	0.062
Res. BH	$111.80	-$64.61 (-$95.33, -$33.63)	0.000	$90.93	-$52.49 (-$84.97, -$20.55)	0.001
IP Non-BH	$188.66	-$89.20 (-$139.40, -$38.57)	0.001	$59.92	-$91.32 (-$146.10, -$37.25)	0.001

Appendix J Supplementary Analyses

Appendix J.1 Demographics of Individuals Enrolled at Month 35

We examined the demographics of those who were still enrolled in Medicaid at Month 35 in the PSH versus comparison groups. To the extent that Medicaid attrition is lower among PSH recipients with chronic health conditions that predispose individuals to need more care than among individuals in the comparison cohort, our estimates may be biased away from finding reductions in spending and changes in utilization associated with receiving PSH. However, there is no difference in proportion of enrollees diagnosed with a variety of chronic conditions between 2011 and 2017. The severity of these conditions may still be different and may be impacting overall spending.

Appendix Table 14: Appendix J.1 Demographics of Individuals Enrolled at Month 35

	PSH (n=687)		Comparison (n=557)		p-value[1]
	n	Col %	n	Col %	
Female, %	412	60.0	348	62.5	0.367
Age, % in category					
22-24	66	9.6	79	14.2	0.007
25-34	205	29.8	192	34.5	
35-44	167	24.3	129	23.2	
45-54	186	27.1	113	20.3	
55+	63	9.2	44	7.9	
Race, % in category					
Non-Hispanic White	445	64.8	344	61.8	0.654
Non-Hispanic Black	215	31.3	190	34.1	
Hispanic	-*	-*	-*	-*	
Other	-*	-*	-*	-*	
Medicaid Managed Care Contracting Region, % in category					
Lehigh	52	7.6	58	10.4	0.460
New East	-*	-*	-*	-*	
New West	69	10.0	59	10.6	
Southeast	-*	-*	-*	-*	
Southwest	525	76.4	410	73.6	
Resident of Allegheny County, %	275	40.0	251	45.1	0.074
Resident of rural county %[2]	199	29.0	165	29.6	0.800
Dual enrollee in Medicare and Medicaid, % [3]	668	97.2	539	96.8	0.630
Eligible for Medicaid through a disability pathway, %[4]	363	52.8	306	54.9	0.460
Diagnoses, %					
Hepatitis C Virus	189	27.5	143	25.7	0.466
Human Immunodeficiency Virus	-*	-*	-*	-*	0.163
Tobacco use disorder	589	85.7	469	84.2	0.451

Appendix Table 14 Continued

	PSH (n=687)		Comparison (n=557)		p-value[1]
	n	Col %	n	Col %	
Substance use disorder	474	69.0	365	65.5	0.195
Mental health diagnosis	659	95.9	537	96.4	0.659
Cardiovascular disease, extra low[5]	376	54.7	298	53.5	0.665
Gastrointestinal, low[5]	405	59.0	319	57.3	0.550
Infectious, low[5]	239	34.8	184	33.0	0.516
Cardiac disease[5]	372	54.1	302	54.2	0.980
Diabetes[5]	108	15.7	87	15.6	0.961

[1]P-value for differences in proportions between the PSH and comparison cohorts. Differences were assessed using Chi-square tests for categorical variables.
[2]Rurality was assessed at the county level according to a definition provided by The Center for Rural Pennsylvania.
[3]If an enrollee had >=1 month in the years 2011-2017 in which they were dually enrolled in Medicare and Medicaid, they were considered to have been a dual enrollee Medicare and Medicaid.
[4]If an enrollee had >=1 month in the years 2011-2017 in which they were enrolled in Medicaid through a disability pathway, they were considered to have been enrolled through a disability pathway.
[5]Categories were assessed using the Chronic Illness & Disability Payment System and Medicaid Rx (CDPS-MRX). "Low" and "extra low" refer to levels of severity. Categories listed here are the top 5 CDPS-MRX categories present in the PSH cohort.
*Cell values haves been suppressed due to small cell sizes.

Appendix J.2 Spending Prior to Baseline

We examined trends in spending 16-27 prior to the baseline period using regression models with a gamma distribution to account both for person-months with $0 in spending and those with very high spending. The first model examined the interaction of treatment group membership with spending in a given month relative to the enrollee's index date. The second model examined the interaction of treatment group with spending averaged over the quarter relative to the enrollee's index date to allow additional flexibility for enrollees churning in and out of Medicaid. In both models, and in both the probit part of the model, modeling $0 spending, and the gamma distribution, modeling spending greater than $0, there was no interaction between month/quarter relative to index date and treatment group membership. There is no difference in the trend in total spending, providing additional support for the assumption that long-run trends would have been expected to remain similar had our treatment sample not received PSH.

Appendix Table 15: Unadjusted Pre-Baseline Spending, Quarterly Model

VARIABLES	(1) Probit Part	(2) Gamma Part
Treatment Group	0.14**	-0.00
	(0.05)	(0.00)
Quarter -8	0.01	-0.00
	(0.03)	(0.00)
Quarter -7	0.02	0.00
	(0.03)	(0.00)
Quarter -6	0.04	0.00
	(0.03)	(0.00)
Treatment # Quarter -7	0.07	0.00
	(0.04)	(0.00)
Treatment # Quarter -6	0.09	0.00
	(0.05)	(0.00)
Treatment # Quarter -5	0.08	-0.00
	(0.05)	(0.00)
Constant	0.22**	0.00**
	(0.04)	(0.00)

Robust standard errors in parentheses
** p<0.01, * p<0.05

Appendix Table 16: Unadjusted Pre-Baseline Spending, Monthly Model

VARIABLES	(1) Probit Part	(2) Gamma Part
Treatment Group	0.13*	-0.00*
	(0.06)	(0.00)
Month -26	0.02	-0.00
	(0.04)	(0.00)
Month -25	-0.03	-0.00
	(0.04)	(0.00)
Month -24	-0.03	-0.00
	(0.04)	(0.00)
Month -23	0.03	-0.00
	(0.04)	(0.00)
Month -22	0.01	-0.00
	(0.05)	(0.00)
Month -21	0.02	-0.00
	(0.05)	(0.00)
Month -20	0.02	-0.00
	(0.05)	(0.00)
Month -19	0.02	-0.00
	(0.04)	(0.00)
Month -18	0.00	0.00
	(0.05)	(0.00)
Month -17	0.02	-0.00
	(0.04)	(0.00)
Month -16	0.09*	0.00
	(0.05)	(0.00)
Treat # Month -26	-0.03	0.00
	(0.05)	(0.00)
Treat # Month -25	0.05	0.00
	(0.06)	(0.00)
Treat # Month -24	0.11	0.00
	(0.06)	(0.00)
Treat # Month -23	0.07	0.00
	(0.06)	(0.00)
Treat # Month -22	0.05	0.00
	(0.06)	(0.00)
Treat # Month -21	0.06	0.00
	(0.06)	(0.00)
Treat # Month -20	0.11	0.00
	(0.06)	(0.00)
Treat # Month -19	0.10	0.00
	(0.06)	(0.00)
Treat # Month -18	0.12	-0.00

Appendix Table 16 Continued

	(0.07)	(0.00)
Treat # Month -17	0.09	0.00
	(0.07)	(0.00)
Treat # Month -16	0.04	-0.00
	(0.07)	(0.00)
Constant	0.22**	0.00**
	(0.04)	(0.00)

Robust standard errors in parentheses
** p<0.01, * p<0.05

Appendix K Allegheny County Data Warehouse Sources

As written in the July 2018 Allegheny County Data Warehouse report by The Allegheny County Department of Human Services.[122] *Bolded items indicate those used in this analysis.*

1. Aging — publicly-funded services and supports provided to individuals age 60 and above
2. **Substance Use — publicly-funded services and supports designed to treat substance use disorders**
3. **Mental Health — publicly-funded services and supports for individuals with a mental health diagnosis**
4. Family Support Centers — publicly-funded services provided to children (age 3 and under) and their families through any of Allegheny County's family support centers
5. **Homeless and Housing Supports — individuals or families receiving housing and supportive services provided by DHS and DHS-contracted providers due to a housing crisis. Services include housing assistance, case management, prevention and outreach.**
6. Allegheny County Jail Collaborative — data on services and supports for offenders, including the Reentry program, designed to prevent recidivism and improve community safety, developed through a partnership of County agencies, the Courts and community organizations
7. **Child Welfare — children and youth 18 years old or younger, and their families, associated with a child welfare allegation, investigation, or case**

8. **Public Housing — low-income individuals receiving housing assistance through the Housing Authority of the City of Pittsburgh and the Allegheny County Housing Authority**
9. **Allegheny County Jail — individuals who are admitted to the Allegheny County Jail and assigned a jail bed.**
10. Public Schools — children and youth enrolled in kindergarten through twelfth grade in one of the DHS data-sharing partner school districts: a. Pittsburgh Public School District b. Clairton City School District c. Duquesne School District d. Penn Hills School District e. Woodland Hills School District f. Propel Charter Schools
11. Adult Probation — data on cases, charges, sentences, violations and detainers for adults supervised by Allegheny County Adult Probation
12. Birth records — birth certificate records of births that occurred among mothers who resided in Allegheny County at the time of delivery
13. **Courts — information on court cases — such as filings, charges, dispositions, and sentences — collected by Magisterial District Courts and the Court of Common Pleas in Allegheny County.**
14. **Public Benefits — individuals who have received services from Allegheny County DHS and who are also receiving public benefits from the Pennsylvania Department of Human Services (PA DHS). PA DHS public benefits include cash assistance, the Supplemental Nutrition Assistance Program (SNAP), help with childcare, health care coverage, home heating assistance (LIHEAP), school meals, Select Plan for Women, and long-term living services.**

15. Intellectual Disability — publicly-funded services provided to individuals over the age of 18 with intellectual disabilitie
16. Early Childhood — infants, toddlers and young children up to three years of age who are receiving Early Intervention (EI) services. EI provides developmental and social emotional screenings, supports and services for young children who have a developmental delay or are at risk for developmental delay.
17. Juvenile Justice — data on allegations, charges, disposition and placements, as well as assessments, for youth under the age of 18 who are supervised by Allegheny County Juvenile Probation
18. Autopsied Deaths — individuals who died in the County and whose deaths were recorded in autopsy reports by the Allegheny County Medical Examiner's Office. The Medical Examiner investigates cases of homicide, suicide, overdose, accidental deaths and natural deaths that are sudden, unexpected or medically unattended.
19. Independent Living — youth ages 14 to 24 who had at least 30 days of placement services with child welfare on or after their 14th birthday and are receiving publicly-funded services designed to prepare them for living independently as adults
20. Labor and Industry — employment, earnings and unemployment insurance benefits information
21. Workforce Training Programs — Partner4Work (formerly known as the 3 Rivers Workforce Investment Board) shares job search assistance, career counseling and vocational training data from Pennsylvania's Commonwealth Workforce Development System

Appendix L Pairwise Correlations Among Potential Mediators and Moderators

Appendix Table 17: Pairwise Correlations Among Potential Mediators and Moderators in Initiation Cohort

	Mental Health Diagnosis	HIV Diagnosis	HCV Diagnosis	Other Medicaid Enrollment	SSI Medicaid Enrollment	Expansion Medicaid Enrollment	Days in Allegheny County Jail	Days in Court, Drug Offenses	Days in Court, Nondrug Offenses	Months with Child Welfare Interaction	Months with Housing Support	Days in Inpatient Setting	Days in ED
Mental Health Diagnosis	1.0000												
HIV	0.0166	1.0000											
HCV	0.0531	0.0103	1.0000										
Other Medicaid Enrollment	-0.0380	-0.0113	-0.0177	1.0000									
SSI Medicaid eligibility	0.1570	0.0338	0.0123	-0.4644	1.0000								
Expansion Medicaid eligibility	-0.1075	-0.0200	0.0064	-0.5709	-0.4620	1.0000							
Days in Allegheny County Jail	0.0455	0.0195	-0.0014	-0.0179	-0.0293	0.0450	1.0000						
Days in Court, Drug Offenses	-0.0370	0.0009	-0.0074	0.0090	-0.0418	0.0298	0.1877	1.0000					
Days in Court, Nondrug Offenses	-0.0130	0.0040	-0.0107	0.0296	-0.0443	0.0114	0.2978	0.6165	1.0000				
Months with Child Welfare Interaction	0.0172	-0.0094	-0.0144	0.1041	-0.0212	-0.0846	0.0503	0.0285	0.0687	1.0000			
Months with Housing Support	0.1082	0.0317	0.0133	0.0132	0.1117	-0.1167	-0.0023	-0.0293	-0.0104	0.0755	1.0000		
Days in Inpatient Setting	0.0577	-0.0032	0.0411	-0.0327	0.0965	-0.0567	-0.0131	-0.0205	-0.0298	-0.0109	0.0235	1.0000	
Days in ED	0.1628	0.0166	0.0308	0.0022	0.1108	-0.1050	0.0512	-0.0054	0.0339	0.0080	0.0720	0.2883	1.0000

Appendix Table 18: Pairwise Correlations Among Potential Mediators and Moderators in Retention Cohort

	Mental Health Diagnosis	HIV Diagnosis	HCV Diagnosis	Other Medicaid Enrollment	SSI Medicaid Enrollment	Expansion Medicaid Enrollment	Days in Allegheny County Jail	Days in Court, Drug Offenses	Days in Court, Nondrug Offenses	Months with Child Welfare Interaction	Months with Housing Support	Days in Inpatient Setting	Days in ED	Urine Drug Test Screening Ratio per 100 OP Visits
Mental Health Diagnosis	1.0000													
HIV	0.0160	1.0000												
HCV	0.0719	-0.0117	1.0000											
Other Medicaid Enrollment	-0.0473	-0.0227	-0.0538	1.0000										
SSI Medicaid eligibility	0.1439	0.0677	0.0350	-0.2814	1.0000									
Expansion Medicaid eligibility	-0.0837	-0.0390	0.0142	-0.5781	-0.6203	1.0000								
Days in Allegheny County Jail	0.0151	0.0280	0.0249	-0.0522	-0.0547	0.0891	1.0000							
Days in Court, Drug Offenses	-0.0485	-0.0138	-0.0076	-0.0302	-0.0654	0.0803	0.1910	1.0000						
Days in Court, Nondrug Offenses	-0.0244	-0.0066	0.0100	-0.0037	-0.0696	0.0623	0.2632	0.6394	1.0000					
Months with Child Welfare Interaction	0.0178	-0.0115	-0.0117	0.1238	-0.0446	-0.0633	0.0505	0.0226	0.0669	1.0000				
Months with Housing Support	0.1241	-0.0125	0.0194	0.0642	0.0970	-0.1349	-0.0328	-0.0272	-0.0213	0.0500	1.0000			
Days in Inpatient Setting	0.0782	0.0006	0.1130	-0.0150	0.1204	-0.0901	-0.0127	-0.0286	-0.0204	0.0291	0.0293	1.0000		
Days in ED	0.1543	-0.0012	0.0887	-0.0459	0.1004	-0.0478	0.0365	0.0094	0.0427	0.0229	0.0637	0.2974	1.0000	
Urine Drug Test Screening Ratio per 100 OP Visits	0.0453	0.0034	-0.0302	0.0497	-0.0628	0.0128	-0.0174	-0.0198	-0.0050	-0.0016	-0.0331	-0.0375	-0.0410	1.0000

Appendix M Sample Size and Power Considerations

Sample size limitations may have played a role in limiting the statistical significance of coefficients in models 4 and 5 for both outcomes. We calculated post-hoc power of the added mediators in these models to determine the probability of finding a statistical significance for that coefficient, given the existence of all the other coefficients in the model, should one exist. Post-hoc power was calculated in G*Power using local f^2 effect size. [123,124]

Appendix Table 19: Power to Detect Significance of Added Coefficients in Initiation Models

	(A4)		(A5)	
	Multivariable Model: Added Mediators without Interactions		**Multivariable w/ Interactions: Added Mediators with Interactions with Race**	
	Power	Significant in Model?	Power	Significant in Model?
Mental Health Diagnosis	0.930	Y	0.053	N
HIV Diagnosis	0.128	N	0.093	N
HCV Diagnosis	0.114	N	0.171	N
Days in Allegheny County Jail	0.873	Y	0.102	N
Days in Court, Drug Offenses	0.060	N	0.318	N
Days in Court, Nondrug Offenses	0.050	N	0.150	N
Months with Child Welfare Interaction	0.101	N	0.281	N
Months with Housing Support	0.409	N	0.134	N
Days in Inpatient Setting	0.058	N	0.124	N
Days in ED	0.992	Y	0.394	N

Appendix Table 19 suggests that given the presence of other covariates in the initiation models, there was not sufficient power available to identify a significant effect, should one exist, for most of the covariates.

Appendix Table 20: Power to Detect Significance of Added Coefficients in Retention Models

	(B4)		(B5)	
	Multivariable Model: Added Mediators without Interactions		**Multivariable w/ Interactions: Added Mediators with Interactions with Race**	
	Power	Significant in Model?	Power	Significant in Model?
Mental Health Diagnosis	0.966	Y	0.125	N
HIV Diagnosis	0.050	N	0.052	N
HCV Diagnosis	0.477	Y	0.133	N
Days in Allegheny County Jail	0.999	Y	0.121	N
Days in Court, Drug Offenses	0.156	N	0.107	N
Days in Court, Nondrug Offenses	0.771	N	0.051	N
Months with Child Welfare Interaction	0.058	N	0.151	N
Months with Housing Support	0.565	Y	0.053	N
Days in Inpatient Setting	0.547	Y	0.057	N
Days in ED	0.999	Y	0.204	N
Urine Drug Test per 100 Outpatient Visits	1.000	Y	0.055	N

Similarly, Appendix Table 20 suggests that given the presence of other covariates in the retention models, there was not sufficient power available to identify a significant effect, should one exist, for most of the covariates. Future research should aim to use larger sample sizes to increase statistical power.

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