Assessing the Impact of Seasonal Factors on HIV Care in the Homeless Population of Pittsburgh

by

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Abstract

Background: Homelessness is a serious public health problem across the United States that is linked to negative health outcomes. Those who are homeless face variable seasonal weather conditions which result in weather-related health concerns, diminished ability to access health care, and fluctuating homeless shelter usage. It is established that those without housing stability are at higher risk for Human Immunodeficiency Virus (HIV), however current literature does not examine how season-specific challenges may affect how HIV care can be managed. This study explores the effect of seasonality on HIV care management among different housing statuses.

Methods: Anonymous aggregate data was obtained from 1,133 patients who visited Allegheny Health Network's (AHN) Positive Health clinic between 01/01/2017 and 12/31/2019. Patients were grouped by their housing status (stable, temporary or unstable) for each year. Patient data was selected only from qualifying summer or winter months. Statistical analyses were performed by the AHN biostatistician.

Results: Excluding winter 2017, those with temporary and unstable housing appeared to have consistently lower rates of viral suppression than the stable housing subgroup. Summer 2017 and summer 2019 both showed weak statistically significant associations between housing status

and viral load suppression. Black individuals were also shown to be more likely unstably or temporarily housed across all three years (2017-2019), and males were more likely to be unstably or temporarily housed in 2017.

Conclusions: The results show those with unstable and temporary housing have consistently lower rates of viral suppression than those stably housed. Additionally, there are clear associations between race and housing status. However, the direct effect of seasonality on HIV viral load management among people with varying housing statuses is unclear and should be further investigated.

Public Health Significance: Current literature concerning HIV, homelessness, and seasonality is limited; however, there are known associations between People Living with HIV and those with unstable housing. Since adverse weather events more severely impact those with unstable housing, seasonality can potentially cause an interruption in the HIV care continuum. To our knowledge, this is the first study in Southwestern Pennsylvania to investigate how seasonal factors affect HIV among different housing subgroups.

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Preface

I would like to thank the Allegheny Health Network and the Positive Health Clinic for allowing me to use data from their electronic medical record from 2017-2019 for my thesis. Without their help and support this research would not be possible. I would like to especially thank Courtney Watson, who was my initial point of contact and brought together a wonderful team to work with me on this project; Samantha Baker, who pulled the data from the electronic medical record; Dr. Bruce Ling, who oversaw the project through AHN; and Rebecca Schorr, who ran the analysis from the AHN data and provided the aggregate tables.

I would also like to thank my committee members, Dr. Sarah Krier, Dr. Mackey Friedman, and Dr. Mary Hawk for their support and feedback to me during this process and throughout my time as an MPH student. Without all of your support, I would never have had the opportunity to investigate this topic.

1.0 Introduction

Homelessness continues to be a pressing problem in the United States. According to the US Department of Housing and Urban Development (HUD), there were roughly 553,000 people experiencing homelessness on a given night in the US in 2018, and this number has been rising over the past two years[1]. Those who are homeless face numerous health barriers and have an average life expectancy that is 17.5 years shorter than that for the general population[2].

1.1 Defining Homelessness

It is difficult to find a consistent definition of homelessness. Within the United States federal government, there are two different major definitions of homelessness: the education definition from Health and Human Services (HHS) and the Housing and Urban Development (HUD) definition, which was updated in 2009 through the Homeless Emergency Assistance and Rapid Transition to Housing (HEARTH) Act. For homeless youth, HHS defined homelessness under the Runaway and Homeless Youth Act (RHYA) [3,4].

The HHS definition of homelessness is the broadest federal definition. It classifies those who are living in unsheltered locations, emergency shelters and transitional housing, welfare hotels, motels and hotels (if there are no other appropriate alternatives), and those who are staying with others (or "doubled-up) as homeless. By comparison, the HUD definition is more restrictive, classifying only those living in unsheltered locations, emergency shelters and transitional housing, or welfare hotels as homeless. In 2009, the HUD definition was undated to include some

exceptions for those living in motels and hotels or who are doubled-up. The education definition, used for many education programs in the US, follows the less restrictive HHS definition.

The 2009 HEARTH Act attempted to create a more standardized definition for homelessness in the US, and the US Interagency Council on Homelessness (USICH) met in 2010 to discuss the topic. The meeting concluded with concerns that creating a standardized definition for homelessness was too resource-intensive for state and local governments, and that if a universal definition was adopted, local agencies serving subgroups of the homeless population may lose access to resources if the population they served did not meet the standardized definition[5]. Many hospital systems and other organizations may follow one of the federal definitions or other different definitions of homelessness depending on their needs as an organization. A summary of federal programs and agencies by homelessness definition can be found in the following table:

Table 1: Homelessness Housing Definitions by Federal Programs/Agencies

	Education Definition	**HUD Definition (Pre-2009)**	**HUD Definition (Post-2009)**	**HHS/RHYA Definition**
Federal Programs and Agencies Using the Definition	• Elementary and Secondary Education • Individuals with Disabilities Education Act • Higher Education Act • Head Start Act • Child Nutrition Act • Violence Against Women Act	• Homeless Assistance Programs through HUD • Emergency Food and Shelter • Department of Veterans Affairs • Department of Labor	• Homeless Assistance Programs through HUD • Emergency Food and Shelter • Department of Veterans Affairs • Department of Labor	• Runaway and Homeless Youth Act Programs
Living Situations Covered by these Definitions	<u>Approved:</u> • Unsheltered Locations • Emergency Shelters and Transitional Housing • Motels and Hotels (if no appropriate alternatives) • Staying With Others/ "Doubled-Up"	<u>Approved:</u> • Unsheltered Locations • Emergency Shelters and Transitional Housing • Welfare Hotels Only <u>Not Approved:</u> • Other Motels and Hotels • Staying With Others/ "Doubled-Up"	<u>Approved:</u> • Unsheltered Locations • Emergency Shelters and Transitional Housing <u>Usually not approved, but there are exceptions:</u> • Motels and Hotels • Staying With Others/ "Doubled-Up"	<u>Approved:</u> • Unsheltered Locations • Emergency Shelters and Transitional Housing • Motels and Hotels (if no appropriate alternatives) • Staying With Others/ "Doubled-Up"

1.2 Homelessness and HIV

The homeless population has been shown to be at higher risk for Human Immunodeficiency Virus (HIV). According to the National Alliance to End Homelessness, 3.4% of the homeless population in the United States has tested positive for HIV compared to the 0.4% from the general population who tested positive for the disease[6]. A San Francisco study also found that those with housing insecurity were also more likely to die from the disease; in the study, those who were homeless had a five year survival rate of 67% after contracting AIDS, compared to a five year survival rate of 81% for those who were stably housed[7].

Financial factors reinforce the problems that both homelessness and HIV present. The high out-of-pocket costs for HIV medication and health care has led to some individuals losing their homes[8]. Between one-third and one-half of people living with HIV (PLWH) in the United States are "homeless, unable to afford their own housing, or at imminent risk of homelessness"[8].

Additionally, those who are homeless or unstably housed experience higher risk for HIV infection. HIV rates are three to nine times higher in the homeless compared to those who are stably housed[9]. Rates of drug and sexual risk behaviors that can lead to HIV are quite high among those who are unstably housed compared to those who are not. In a 2005 study, 55% of homeless were reporting recent hard drug use compared to the 17% who reported the drug use among stably housed individuals; similarly, 17% of the homeless recently used a needle to inject those drugs compared to 5% of stably housed individuals[10]. Concerning sexual behavior, the same study found that 15% of unstably housed individuals exchanged sex for money, drugs, or a place to stay in the previous 6 months compared to less than 5% of those who were stably housed doing the same[10]. However, it was half as likely for those who were homeless to engage in protected sex with a condom compared to those who were stably housed[10].

Additional risk factors also serve to affect both HIV and homelessness. Stigma and poor mental health are also factors that are shared between HIV and homelessness[11, 12, 13, 14]. Other circumstances, such as time in prison, divorce, eviction, and domestic violence, can also act as risk factors for homelessness[11, 12].

1.3 Seasonal Factors Affecting the Homeless

The homeless population is at increased risk for cold-weather related conditions, such as hypothermia or frostbite [2,15,16]. According to a Toronto study, 25% of hypothermia related visits were by individuals who met the hospital criteria for homelessness. Additionally, 23% of hypothermia-related deaths occurred in homeless individuals[16]. A study in New York City shows similar results. While only 1% of emergency room visits relating to cold-weather related conditions were made by the homeless (defined by the hospital), this small percentage of visits resulted in 24% of the hospital admissions for the city[15].

Though one would expect higher emergency use during the winter months as a result of increased health problems associated with the weather, studies have found that there is no statistically significant correlation between emergency department attendance among the homeless and the winter season versus other times of the year[17, 18]. However, there was a correlation between daily attendance at the ER and minimum daily temperature[17]. This is likely because, as the weather reached colder extremes, it because more likely that one would contract these acute conditions cold weather conditions, especially when exposed to the cold temperatures for extended periods of time.

When the homeless go to the emergency department, they are more likely to leave before seeing a physician than the general population[15,16]. The lengthy wait times were most commonly cited for this issue, though overcrowding and an influx of trauma patients were also listed[16]. In the Toronto study, ~20% of homeless individuals who were symptomatic for hypothermia left before seeing a doctor or being formally diagnosed[16].

Both shelter use and the availability of shelters fluctuate seasonally. Many cities, including Pittsburgh, operate winter shelters from mid-fall to early spring to accommodate for the dropping temperatures and increase in adverse weather events that cause the use of these shelters to spike[19]. Climate change is another potential concern for the health of the homeless. As climate change continues, vulnerable populations like the homeless will be further affected by extreme weather events both during cold and hot temperature fluctuations[20].

1.4 Homelessness in Pittsburgh

In the city of Pittsburgh, homelessness remains a persistent problem. Though the Allegheny County health department released a report showing that the number of homeless individuals has decreased in Pittsburgh from 1492 people in 2013 to 1145 people in 2017, Pittsburgh news articles indicate that the number of homeless may have risen in the city[21,22]. The discrepancy in tracking homelessness in Pittsburgh may be due to using point-in-time (PIT) counts to gage the population. This method estimates the annual homeless population based on taking a count at one point during the year. As a result, any seasonal variations in the number of homeless are missed through this method. In the 2017 Allegheny County report, the 2017 PIT count occurred in January. The time

of year may affect how many people use services like shelters or other services and may affect the accuracy of the count.

Though Allegheny County saw the total PIT count drop between 2015 and 2019, both the number of homeless using emergency shelters or who were unsheltered rose steadily from 2015, reaching their peaks in 2017 and 2018, respectively[22,23]. Meanwhile, the numbers of those using transitional housing and safe haven services dropped[22,23].

Table 2: Pittsburgh PIT Counts from January 2015-2019

	Emergency Shelter	Safe Haven	Transitional Housing	Unsheltered	Total PIT Count
January 2015	440	69	877	38	1424
January 2016	260	54	594	48	1156
January 2017	622	22	448	53	1145
January 2018	575	6	146	56	783
January 2019	568	7	151	48	774

This could mean that those who are homeless are failing to reach services designed to provide them more stable shelter.

The Allegheny County Department of Human Services included PIT Homelessness Data for both January and July in their 2019 report[23].

Table 3: Pittsburgh PIT Counts from January and July 2019

	Emergency Shelter	Safe Haven	Transitional Housing	Unsheltered	Total PIT Count
January 2019	568	7	151	48	774
July 2019	469	7	77	185	738

This data indicates that the number of homeless using emergency shelters fell in July compared to January, while the number of homeless who were unsheltered rose. This is consistent with studies done on how emergency shelter use fluctuates at different times of year across the United States.

1.5 HIV Care Continuum

The HIV care continuum is a public health model which outlines the steps between becoming infected with HIV and maintaining viral suppression. The first step in the HIV care continuum is to receive a positive diagnosis[24]. Next, the individual must be linked to a HIV health care provider within one month of learning they have tested positive[24]. Then, they must retain that care after the initial visits and receive medical treatment for HIV[24]. Finally, they must reach viral suppression by adhering to the medications and treatment for HIV[24].

A 2016 HIV Prevention and Care Plan published by the PA Department of Health showed the percentages of those living with HIV in Pennsylvania at each stage of the care continuum. In 2015, 89% were diagnosed with HIV; 59.8% were linked to an HIV care provider; 39.3% were retained in that care; ad 18.2% had a suppressed viral load, which was defined as having fewer than 50 copies per mL[25].

As this data shows, there can be an interruption at any of these steps which will subsequently impact each of the following steps and lead to a lower likelihood of viral suppression. This study views adverse weather events caused by seasonality as a potential outside factor that could interrupt the care continuum

1.6 Summary

In summary, homelessness remains a problem in many areas throughout the United States, including Pittsburgh. Despite this being a widespread problem, homelessness has been difficult to define and track throughout this country.

The homeless are also at increased health risk for HIV and are three to nine times as more likely to have the virus compared to an individual with stable housing; they are also more likely to die from the disease. There is an established link between HIV and homelessness, which clearly shows that the homeless population is disproportionately burdened by the disease.

Additionally, the health of the homeless can be adversely affected by seasonal change, which can lead to health problems and the need for medical treatment. The increased stress due to the exposure to fluctuating weather conditions may affect how HIV care is managed in the homeless population.

2.0 Methods

This data was obtained from the Allegheny Health Network's (AHN) Positive Health Clinic (PHC), an HIV care clinic in Pittsburgh, using the most recent three years of data. The analysis was performed by a biostatistician from AHN.

2.1 Purpose and Research Question

This study seeks to highlight the effect of seasonality on homelessness and establish a background to understand the potential effects of seasonality on HIV care management in different housing statuses.

This paper seeks to answer the question, "How does seasonality impact HIV management in the homeless population?"

2.2 IRB Approval

An application for an IRB exemption was submitted to the University of Pittsburgh under the "No Human Subjects" exemption and was approved December 13, 2019, as only secondary data was used for this research.

An application for an IRB exemption was then submitted to the Allegheny Health Network and was approved on March 2, 2020, as only aggregate data would be provided by the Allegheny Health Network and would not be identifiable to any individual patients.

2.3 Study Subjects

Data were stratified by the covariates listed below, comparing outcomes for those who were stably housed to those without stable housing (i.e. temporary or unstable housing).

Table 4: Table of Variables

Predictors	Outcome	Covariates
- homelessness status - weather conditions (based on date of visit)	- HIV viral loads	- age - gender -sexual behavior - drug use - race - ethnicity

This study design grouped data by yearly housing status designation (stable, temporary, or unstable housing). In order to ensure that the assumption of independence was met, only the last visit of the continuous season (i.e. April for winter or October for summer), was taken from each individual per season. A visit is only included in this study when an HIV viral load count is taken.

For the purposes of this study, homeless is defined through the HUD definition of homelessness, as related to the Ryan White HIV/AIDS Program. Under this, unstable housing follows the HUD definition of homelessness, which includes living in unsheltered locations, emergency shelters and transitional housing, or welfare hotels; and temporary housing includes those with short-term housing plans, such as those who are in hotels and motels or who are living doubled-up.

2.4 Measures

Climate data was obtained for the months between January 2017 to December 2019 through the National Oceanic & Atmospheric Administration (NOAA) using the Pittsburgh Allegheny County Airport station (Lat: 40.3547°N, Lon: -79.9217°W). For the purposes of this study, summer months are considered months between April and October with an average temperature of higher than 65.0 degrees Fahrenheit, and winter months are considered months between October and April with an average temperature of lower than 45.0 degrees Fahrenheit. The table below shows the monthly temperature data and seasonal designations:

Table 5: Summary of 2017-2019 Monthly Recorded Temperatures in Pittsburgh, PA

		Temperature (°F)			
		High	Low	Average	Designation
2017	January	65	5	35.4	Winter
	February	77	57	41.4	Winter
	March	75	14	40.2	Winter
	April	86	31	57.8	-
	May	87	37	60.9	-
	June	90	50	69.7	Summer
	July	89	55	73.6	Summer
	August	90	53	70	Summer
	September	89	46	66.3	Summer
	October	82	33	58.6	-
	November	69	17	42.8	Winter
	December	58	1	29.2	Winter
2018	January	65	-5	26	Winter
	February	77	10	38.9	Winter
	March	64	20	34.7	Winter
	April	83	26	46.2	-
	May	89	42	68.5	Summer
	June	90	47	70	Summer
	July	94	55	74.1	Summer
	August	90	54	73.5	Summer
	September	92	52	69.2	Summer
	October	84	31	54.3	-

Table 5 Continued

	November	65	20	38.1	Winter
	December	64	17	36.6	Winter
2019	January	61	-5	28.6	Winter
	February	63	7	34.7	Winter
	March	78	7	37.9	Winter
	April	80	25	54.7	-
	May	86	40	64.5	-
	June	88	44	68.4	Summer
	July	92	57	75.2	Summer
	August	87	53	71.8	Summer
	September	90	49	69.8	Summer
	October	89	35	56.9	-
	November	63	13	38.4	Winter
	December	62	11	36.5	Winter

All other data pertaining to HIV viral load data and demographic information were obtained from PHC from the electronic medical record and provided as aggregate data. Data was obtained from 01/01/2017 to 12/31/2019. Only the last visit of a given season for any one individual was included for analysis to control for repeated measures. No data was obtained through direct intervention or interaction with any individual patient.

2.5 Analysis

Statistical analyses were performed by the AHN biostatistician. A summary of the demographics data for the sample was aggregated and presented without statistical analysis. Continuous variables were presented as mean (standard deviation) when classified as normal and were otherwise presented as median [interquartile range (IQR)]. Categorical variables were presented as frequency (n), percent of total within group (%). Housing groups from 2017-2019 were each analyzed for confounders of gender, sexual behavior, race, and ethnicity. The categories in the housing analyses were treated as categorical variables. Categorical variables were analyzed by chi-square or Fisher's exact test as appropriate.

The chi square analyses from tables 8A, 8B, and 8C were reengineered to obtain the chi square statistic, as originally, only the p-values were provided by AHN. In these analyses, the variables were assumed to be dichotomous, and a synthetic data set was created to match the known aggregate data. The reengineered p-values were then compared to the values provided by AHN and were found to closely match. Similarly, the Fisher's exact test and chi square analysis for table 10 was performed using the aggregate data provided. Again, dichotomous variables were assumed, as only the percent virally unsuppressed and the n were provided by AHN. This analysis had no p-value for comparison.

3.0 Results

The following data was obtained through the Allegheny Health Network.

Table 6: Demographic Data for the Study Population

Variable	n=1133	
Age (in years)	50 (38-57)	
Gender (male, female)	947 (84%)	186 (16%)
Sexual behavior (MSM, non-MSM)	773 (68%)	360 (32%)
Race (Black, non-Black)	454 (40%)	679 (60%)
Ethnicity (Hispanic, non-Hispanic)	35 (3.1%)	1098 (97%)
Current drug use (yes within 6 months of visit)	99 (1.5%)	
Total appointments Completed appointments Incomplete appointments	15361 8923 (58%) 6438 (42%)	
2017 housing Stable Temporary Unstable	n=968 821 (85%) 100 (10%) 47 (4.9%)	
2018 housing Stable Temporary Unstable	n=980 791 (81%) 118 (12%) 71 (7.2%)	
2019 housing Stable Temporary Unstable	n=973 790 (81%) 109 (11%) 74 (7.6%)	
Viral load, lab	20 (20 – 43)	

Categorical variables are presented as frequency (percent of total with a group), while the continuous variable of viral load is presented as median (interquartile range (IQR)). Viral load data is presented as the number of copies per cubic milliliter.

It should be noted that only data from completed appointments could be used in this study, and of the total number of scheduled appointments, only 58% were completed. The percent of patients from the three housing subgroups were relatively consistent. Between 2017 and 2019,

PHC patients with stable housing ranged from 81%-85%, those with temporary housing ranged from 10%-12%, and those with unstable housing ranged from 4.9%-7.6%.

Table 7: Summary of Pittsburgh Weather Data

Qualifying months	N=28
High Temperature	83.5 (65-89)
Low Temperature	32 (14-50)
Average Temperature	55.8 (38-69)
Summer months (of qualifying; of total)	13 (46%; 36%)
Winter month (of qualifying; of total)	15(54%; 42%)

This table displays a summary of the Pittsburgh weather data from January 2017 to December 2019. Temperature data is presented in degrees Fahrenheit and is displayed as median (interquartile range (IQR)). Qualifying months are displayed as frequency (percent of qualifying months; percent of total months).

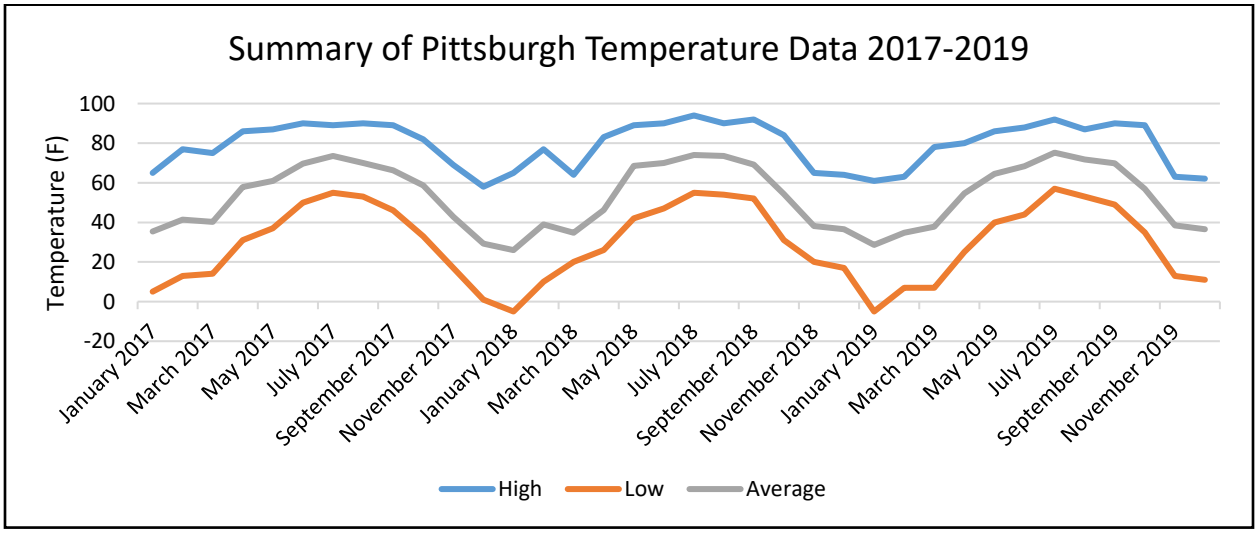

Figure 1: Graph of Pittsburgh Weather from January 2017 to December 2019

This figure depicts the high, average, and low monthly temperatures measured in Pittsburgh between the months of January 2017 and December 2019 in degrees Fahrenheit.

The expected cyclic weather patterns for the Pittsburgh area were apparent during each of the three years (2017-2019).

Table 8A: Distribubtion of Gender, Sexual Behavior, Race, and Ethnicity among 2017 Housing Statuses

Demographic Factors		Total n=966	Unstable Housing 2017 n=47 (4.9%)	Temporary Housing 2017 n=100 (10%)	Stable Housing 2017 n=821 (85%)	P-value	Chi Square Statistic
Gender	Male	808 (83%)	37 (4.6%)	75 (9.3%)	696 (86.1%)	0.031	6.98
	Female	160 (17%)	10 (6.3%)	25 (15.6%)	125 (78.1%)		
Sexual Behavior	MSM	653 (67%)	27 (4.1%)	61 (9.3%)	565 (86.5%)	0.094	4.738
	Non-MSM	315 (33%)	20 (6.3%)	39 (12.4%)	256 (81.3%)		
Race	Black	385 (40%)	31 (8.1%)	62 (16.1%)	292 (75.8%)	<0.0001	40.142
	Non-Black	583 (60%)	16 (2.7%)	38 (6.5%)	529 (90.7%)		
Ethnicity*	Hispanic	31 (3.2%)	3 (9.7%)	4 (12.9%)	24 (77.4%)	0.25	1.9453
	Non-Hispanic	937 (97%)	44 (4.7%)	96 (10.2%)	797 (85.1%)		

*Fisher's exact test was used to obtain p-value for Ethnicity

This table shows an analysis of the categorical variables (gender, sexual behavior, race, and ethnicity) and 2017 housing status by chi-square test. The Fisher's exact test was used to obtain the p-value for ethnicity, as the sample size was small. The categorical variables are presented as frequency (percent of total within group).

Table 8B: Distribubtion of Gender, Sexual Behavior, Race, and Ethnicity among 2018 Housing Statuses

Demographic Factors		Total n=980	Unstable Housing 2018 n=71 (7.2%)	Temporary Housing 2018 n=118 (12%)	Stable Housing 2018 n=791 (81%)	P-value	Chi Square Statistic
Gender	Male	816 (83%)	56 (6.9%)	92 (11.3%)	668 (81.9%)	0.13	4.16
	Female	164 (17%)	15 (9.1%)	26 (15.9%)	123 (75.0%)		
Sexual Behavior	MSM	666 (68%)	41 (6.2%)	75 (11.3%)	550 (82.6%)	0.069	5.35
	Non-MSM	314 (32%)	30 (9.6%)	43 (13.7%)	241 (76.8%)		
Race	Black	396 (40%)	43 (10.9%)	79 (19.9%)	274 (69.2%)	<0.0001	57.43
	Non-Black	584 (60%)	28 (4.8%)	39 (6.7%)	517 (88.5%)		
Ethnicity*	Hispanic	28 (2.9%)	4 (14.3%)	2 (7.1%)	22 (78.6%)	0.28	2.56
	Non-Hispanic	952 (97%)	67 (7.0%)	116 (12.2%)	769 (80.8%)		

*Fisher's exact test was used to obtain p-value for Ethnicity

This table shows an analysis of the categorical variables (gender, sexual behavior, race, and ethnicity) and 2018 housing status by chi-square test. The Fisher's exact test was used to obtain the p-value for ethnicity, as the sample size was small. The categorical variables are presented as frequency (percent of total within group).

Table 8C: Distribubtion of Gender, Sexual Behavior, Race, and Ethnicity among 2019 Housing Statuses

Demographic Factors		Total n=973	Unstable Housing 2019 n=74 (7.6%)	Temporary Housing 2019 n=109 (11%)	Stable Housing 2019 n=790 (81%)	P-value	Chi Square Statistic
Gender	Male	805 (83%)	58 (7.2%)	84 (10.4%)	663 (82.4%)	0.12	4.22
	Female	168 (17%)	16 (9.5%)	25 (14.9%)	127 (75.6%)		
Sexual Behavior	MSM	655 (67%)	42 (6.4%)	69 (10.5%)	544 (83.1%)	0.067	5.41
	Non-MSM	318 (33%)	32 (10.1%)	40 (12.6%)	246 (77.4%)		
Race	Black	395 (41%)	47 (11.9%)	71 (18.0%)	277 (70.1%)	<0.0001	53.37
	Non-Black	578 (59%)	27 (4.7%)	38 (6.6%)	513 (88.8%)		
Ethnicity*	Hispanic	24 (2.5%)	3 (12.5%)	1 (4.2%)	20 (83.3%)	0.36	1.88
	Non-Hispanic	949 (98%)	71 (7.5%)	108 (11.4%)	770 (81.1%)		

*Fisher's exact test was used to obtain p-value for Ethnicity

This table shows an analysis of the categorical variables (gender, sexual behavior, race, and ethnicity) and 2019 housing status by chi-square test. The Fisher's exact test was used to obtain the p-value for ethnicity, as the sample size was small. The categorical variables are presented as frequency (percent of total within group).

A statistical analysis of categorical variables by housing status show that the housing status differed significantly by race over all three years (2017-2019), and gender distribution was significantly different in 2017. This analysis highlights the link between race and housing status in Pittsburgh. It shows that among all three year groups, Black individuals were disproportionately more likely to be unstably or temporarily housed compared to other non-Black individuals.

Table 9: Viral Load Aggregate Data by Housing Status 2017-2019

2017 Housing								
	VL 2017 Summer				VL 2017 Winter			
	N	Mdn (IQR)	Min, Max	VL Unsuppressed	N	Mdn (IQR)	Min, Max	VL Unsuppressed
Stable Housing	514	20 (20 - 40)	20, 1020000	51 (10%)	573	20 (20 - 32)	20, 210000	44 (8%)
Temporary Housing	71	21 (20 - 144)	20, 1294384	16 (23%)	76	20 (20 - 47.5)	20, 71483	10 (13%)
Unstable Housing	29	20 (20 - 39)	20, 68503	4 (14%)	37	20 (20 - 20)	20, 596	2 (5%)
Total	614			71 (12%)	686			56 (8%)
2018 Housing								
	VL 2018 Summer				VL 2018 Winter			
	N	Mdn (IQR)	Min, Max	VL Unsuppressed	N	Mdn (IQR)	Min, Max	VL Unsuppressed
Stable Housing	564	20 (20 - 20)	20, 48138	22 (4%)	482	20 (20 - 20)	20, 311855	24 (5%)
Temporary Housing	85	20 (20 - 28)	20, 47816	5 (6%)	79	20 (20 - 22.5)	20, 66200	6 (8%)
Unstable Housing	49	20 (20 - 20)	20, 337424	5 (10%)	47	20 (20 - 22)	20, 261488	6 (13%)
Total`	698			32 (5%)	608			36 (6%)
2019 Housing								
	VL 2019 Summer				VL 2019 Winter			
	N	Mdn (IQR)	Min, Max	VL Unsuppressed	N	Mdn (IQR)	Min, Max	
Stable Housing	479	20 (20 - 20)	20, 160000	27 (6%)	245	20 (20 - 22)	20, 184210	
Temporary Housing	65	20 (20 - 27)	20, 1065857	4 (6%)	34	20 (20 - 47)	20, 200000	
Unstable Housing	48	20 (20 - 23.5)	20, 40554	8 (17%)	31	20 (20 - 20)	20, 1040538	
Total	592			39 (7%)	310			

This table shows viral load data by housing status for each of the three years observed. Viral loads are presented as continuous variable with median (interquartile range (IQR)), and min, max. Viral unsuppression is presented as a categorical variable with frequency (percent of total within group). Viral load data is presented as number of copies per cubic milliliter.

Table 10: **Chi Square Test of Viral Suppression by Seasonal Housing Status (2017-2019)**

SUMMER 2017					
	N	Unsuppressed Viral Load	Suppressed Viral Load	Fisher's Exact P-Value	Chi Square Statistic
Stable	514	51 (10%)	463 (90%)	0.01	9.85
Temporary	71	16 (23%)	55 (77%)		
Unstable	29	4 (14%)	25 (86%)		
WINTER 2017					
	N	Unsuppressed Viral Load	Suppressed Viral Load	Fisher's Exact P-Value	Chi Square Statistic
Stable	573	44 (8%)	529 (92%)	0.24	3.08
Temporary	76	10 (13%)	66 (87%)		
Unstable	37	2 (5%)	35 (95%)		
SUMMER 2018					
	N	Unsuppressed Viral Load	Suppressed Viral Load	Fisher's Exact P-Value	Chi Square Statistic
Stable	564	22 (4%)	542 (96%)	0.10	4.47
Temporary	85	5 (6%)	80 (94%)		
Unstable	49	5 (10%)	44 (90%)		
WINTER 2018					
	N	Unsuppressed Viral Load	Suppressed Viral Load	Fisher's Exact P-Value	Chi Square Statistic
Stable	482	24 (5%)	458 (95%)	0.07	5.12
Temporary	79	6 (8%)	73 (92%)		
Unstable	47	6 (13%)	41 (87%)		
SUMMER 2019					
	N	Unsuppressed Viral Load	Suppressed Viral Load	Fisher's Exact P-Value	Chi Square Statistic
Stable	479	27 (6%)	452 (94%)	0.02	8.65
Temporary	65	4 (6%)	61 (94%)		
Unstable	48	8 (17%)	40 (83%)		

This table shows an analysis of the categorical variable of viral suppression by seasonal housing status by chi square test. The Fisher's exact test was used to obtain the p-values, as the sample sizes were small. The viral suppression and unsuppresion rates are presented as frequency (percent of total within group).

The raw data presented in table 9 shows that, with the exception of winter 2017, temporary and unstable housing both had consistently lower rates of viral suppression than the stable housing subgroup. When the chi square and Fisher's exact tests were performed, shown in table 10, summer 2017 and summer 2019 both showed statistically significant associations between housing status and viral load suppression. In these two seasons, viral suppression was lower for those with unstable housing compared to the other subgroups. However, winter 2017, summer 2018, and winter 2018 did not show any statistically significant association through the chi square test.

4.0 Discussion

This paper aims to investigate the potential links between seasonality and viral load across different housing statuses in Pittsburgh, PA. The analyses did show some association between viral suppression and housing status during the some of the warmer seasons but did not show any association between viral load and seasonality when housing status was not accounted for.

The results in tables 9 and 10 show that unstable and temporary housing do consistently have lower rates of viral suppression than those stably housed. In the analysis of seasonality and viral load, the analyses of summer 2017 and summer 2019 showed a statistically significantly association between housing status and viral suppression, whereas no statistically significant association was seen in winter 2017, summer 2018, or winter 2018. This indicates that there may be a weak link between viral suppression and the warmer months, which could be due to the increased likelihood of those who are homeless living in unsheltered areas. However, more studies should be performed to investigate these findings.

Additionally, there are clear disparities between race and housing status across all three years of data, with Black individuals being more likely to be unstably or temporarily housed. There does not appear to be a similar correlation between housing status and sexual behavior or ethnicity.

4.1 Public Health Significance

While current existing literature does not investigate how HIV and homelessness are affected by changing weather conditions, current research does show that those without housing

stability are at higher risk for HIV than those with stable housing and that the two factors are closely linked. Current literature also shows that those with unstable housing are more adversely affected by fluctuating weather conditions, primarily in the form of acute conditions, such as hypothermia. However, multiple instances of adverse weather events can lead to a disconnect in the HIV care continuum, where missed appointments or difficulty in obtaining medication can lead to reduced viral suppression of HIV in those who are infected. An individual experiencing HIV, housing insecurity, and seasonal changes faces a variety of challenges, which keeps them from prioritizing health in the same ways that those not affected by these factors would. As a result, the combination of these public health issues creates more frequent negative health outcomes than would otherwise occur.

This study finds that, in Pittsburgh, there were statistically significant ties between viral load and housing status during the two of the three summer seasons observed, whereas no significant associations were found in the two winter seasons observed. This study also shows that in Pittsburgh, there is a clear association between race and housing status; namely, Black participants were more likely to be unstably housed compared to non-Black participants. To our knowledge, this is the first study in Southwestern Pennsylvania to investigate how seasonal factors affect HIV among different housing subgroups.

4.2 Limitations

The initial review of the background literature faced challenges due to the limited data on the effect of HIV care for the homeless across different seasons. Research that has been performed

has been done across a variety of countries, which have different health care systems. These unique systems can present a range of barriers for HIV care for the homeless in different countries.

A primary limitation when beginning this study was the lack of a consistent definition for homelessness. The definition for homelessness is variable, leading to different classifications for who qualifies as "homeless." The initial literature review faced this limitation, as it was a comparison of literature with different homelessness definitions. However, for the statistical analysis portion of the study, this limitation was remedied through the use of the AHN definition, which adheres to the post-2009 HUD definition.

In the analyses of tables 8A, 8B, and 8C, race was shown to be statistically significantly associated with housing status across all three years of the study. Therefore, it is possible that race may act as a confounding variable in the analyses of this data.

Additionally, for the analysis portion of the paper, only completed visits could be used, which constituted only 58% of all scheduled appointments. It is possible that there is some confounding factor related to this missing data and the trends observed. The statistical analyses of tables 8A, 8B, 8C, and 10 also face limitations, as they were based on the aggregate data provided by AHN. In these analyses, the variables were assumed to be dichotomous, and the analyses do not account for multiple categories within a subgroup. Therefore, there is a potential for inaccuracy within these modified methods.

Lastly, the unexpected emergence of COVID-19 lead to limitations in what analyses could be performed during the crisis, as the AHN resources were shifted to address the onslaught of the virus. As a result, some analyses initially requested were unable to be performed, namely a statistical analysis of HIV viral load data in summer compared to winter among the three

designated housing statuses. However, data displaying the continuous variables for this data are present with no statistical component.

4.3 Future Directions

This paper explores a novel topic concerning seasonality's impact on HIV viral load in populations with varying housing status. While there is established research on the challenges those who are homeless face and how seasonality can affect homelessness, there is currently limited data on the effect of HIV care management for the homeless across different seasons. More in-depth studies should be performed to assess the impact of seasonality among vulnerable housing subgroups, both in Pittsburgh, as well as in other geographic areas.

5.0 Conclusion

From the literature, it is clear that the homeless population is a population that is more adversely affected by HIV than the general population. They are also uniquely affected by the weather due to their lack of housing. The weather affects the health of the homeless population, particularly through hypothermia. Although visits to the emergency department do not seem to be affected by the seasonal weather, the daily weather can impact emergency department visits. While there are seasonal barriers for the homeless population, the direct effect of these barriers on HIV management is unknown and should be further investigated.

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