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Impact of Multicomponent Support Strategies on Human Immunodeficiency Virus Virologic Suppression Rates During Coronavirus Disease 2019: An Interrupted Time Series Analysis

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Background. After coronavirus disease 2019 (COVID-19) shelter-in-place (SIP) orders, viral suppression (VS) rates initially decreased within a safety-net human immunodeficiency virus (HIV) clinic in San Francisco, particularly among people living with HIV (PLWH) who are experiencing homelessness. We sought to determine if proactive outreach to provide social services, scaling up of in-person visits, and expansion of housing programs could reverse this decline.

Methods. We assessed VS 24 months before and 13 months after SIP using mixed-effects logistic regression followed by interrupted time series (ITS) analysis to examine changes in the rate of VS per month. Loss to follow-up (LTFU) was assessed via active clinic tracing.

Results. Data from 1816 patients were included; the median age was 51 years, 12% were female, and 14% were experiencing unstable housing/homelessness. The adjusted odds of VS increased 1.34 fold following institution of the multicomponent strategies (95% confidence interval [CI], 1.21–1.46). In the ITS analysis, the odds of VS continuously increased 1.05 fold per month over the post-intervention period (95% CI, 1.01–1.08). Among PLWH who previously experienced homelessness and successfully received housing support, the odds of VS were 1.94-fold higher (95% CI, 1.05–3.59). The 1-year LTFU rate was 2.8 per 100 person-years (95% CI, 2.2–3.5).

Conclusions. The VS rate increased following institution of the multicomponent strategies, with a lower LFTU rate compared with prior years. Maintaining in-person care for underserved patients, with flexible telemedicine options, along with provision of social services and permanent expansion of housing programs, will be needed to support VS among underserved populations during the COVID-19 pandemic.

Keywords. COVID-19; HIV virologic suppression; housing support; telemedicine; homelessness.

The coronavirus disease 2019 (COVID-19) pandemic could have lasting effects on the human immunodeficiency virus (HIV) epidemic [1, 2]. Following the shelter-in-place (SIP) order on 16 March 2020 in San Francisco, California, there were citywide directives to cancel nonessential services and divert in-person medical visits to telemedicine visits when possible. As other jurisdictions followed suit, there was a 60% drop in ambulatory care volume throughout the United States [3]. Data on the impact of the COVID-19 pandemic on HIV virologic suppression (VS) are mixed [4–16]. In San Francisco, there was a citywide decrease in VS among all people living with HIV (PLWH) from 75% in 2019 to 70% in 2020, with VS rates among PLWH experiencing homelessness decreasing from 39% to 20% [17]. At San Francisco General Hospital's Ward 86 HIV Clinic, a pivot to telemedicine was associated with worsening VS soon after the SIP order, with disproportionate impacts among housing-insecure PLWH [18]. Ward 86 is a safety-net clinic that serves approximately 2000 patients per year who are predominantly uninsured or publicly insured. PLWH may experience disparities in access to telemedicine services in the context of a digital divide in which underserved populations may not have reliable phone/internet access, technological literacy, or private spaces to perform telemedicine visits [19].

In response to concerns that the COVID-19 pandemic would compromise services, the Ward 86 Clinic instituted multicomponent support strategies to assist patients

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throughout the pandemic, including proactive outreach to provide food assistance; medication delivery; mental health, substance use, and housing support services; resumption of full in-person care availability; and maintenance of a low-barrier high-intensity drop-in program for PLWH experiencing homelessness (the "POP-UP program" [6]). These clinic programs were bolstered by municipal programs to provide supportive temporary housing within unused hotel rooms [20].

In this analysis, we sought to examine the impact of these multicomponent strategies on VS using both pre- and post-analysis and interrupted time series (ITS) methodology. Given citywide worsening of VS, particularly among PLWH experiencing homelessness [17], our goal in this analysis was to understand if multicomponent support strategies improved VS after an initial destabilization [18].

METHODS

We examined VS (<200 copies/mL) trends 2 years prior to SIP starting from 16 March 2018, with analysis continuing through 31 March 2021. Visit data and tracing data were available through 30 June 2021. The active clinic cohort was defined as participants who had at least 2 visits in the 24 months prior to 16 March 2020 and who also had at least 1 clinic visit and at least 1 HIV viral load measured in the 6 months prior to SIP; those deceased prior to SIP were excluded. The University of California–San Francisco Institutional Review Board approved this research, with informed consent not required given the use of previously collected data for quality improvement efforts.

Description of the Multicomponent Strategies

Beginning 23 March 2020, medical assistants, nurses, clinicians, or trained volunteers performed outreach in order to systematically contact patients by phone or during a clinical visit. Patients were offered referrals to social workers for food insecurity and mental health, substance use, or housing resources. The initial wave of outreach was completed by 30 June 2020 and was repeated approximately quarterly. Capability for in-person visits was returned to near full capacity after the first 2 weeks of SIP, supported by symptom screening, universal masking, use of personal protective equipment, social distancing measures, and improved ventilation. A preexisting program for people with unstable housing and virologic nonsuppression, the POP-UP program, which includes incentives, drop-in availability, and a dedicated nurse and social worker, resumed in-person drop-in visits at this point [6]. People experiencing homelessness at risk of severe COVID-19 disease were offered SIP hotels beginning 19 March 2020, where access to nurses and clinicians was provided on site, while additional housing sites were purchased by the city and turned into permanent supportive housing [20].

Analysis of Change in VS

First, we performed a pre- and post-analysis of the time periods before and after the multicomponent strategies, adjusting for sex at birth, age as a continuous variable, race/ethnicity, housing status assessed at the beginning of SIP (experiencing homelessness/unstable housing vs housed; also assessed at the end of the analysis period), and the presence of severe mental illness based on *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10) codes [21], using mixed-effects logistic regression. A random effect was included for the participant over multiple laboratory assessments. Factors for which the association with outcomes differed pre- and post-SIP (interaction *P* value of $< .1$) are presented with separate effect estimates by time interval obtained via post-estimation commands.

ITS analysis is a quasi experimental design used to analyze outcomes at multiple time points before and after an intervention, with changes in slope over time providing the strongest evidence of intervention impact [22]. For the ITS analysis, we examined mean VS over multiple month-long time points, 24 months prior to SIP and 13 months after, comparing differences in the slope over time following a 2-week lag. We used a 2-week lag to give time for the intervention to take effect because all of the interventions were initiated during this 2-week period.

Loss to Follow-up

After determining the crude loss to follow-up (LTFU) over the post-SIP period, we then requested a match of the Ward 86 data with the San Francisco Department of Public Health (SFDPH) enhanced HIV/AIDS Reporting System. Individuals with viral load measurements completed outside of Ward 86 were assumed retained in care. Finally, for the remaining individuals, active clinic tracing was performed using active outreach to the participant and emergency contacts. Individuals who were known to be out of care or who could not be located were assumed lost to follow-up, with censoring at known LFTU or death [23].

Propensity Score Analysis for Pre- and Post-Intervention VS

As an alternate modeling strategy for the viral load outcome, we constructed a propensity score model to estimate the odds of having a viral load measured pre- and post-SIP, adjusting for sex at birth, race/ethnicity, experiencing homelessness or unstable housing (both vs housed), and the presence of severe mental illness based on ICD-10 codes, with age and CD4+ count included via cubic splines. After propensity scores were stratified into quintiles, we checked for evidence of interaction between the exposure and propensity scores; balance for key confounders was examined across these 5 strata (Supplementary Table 1). We then calculated the marginal odds ratio for viral nonsuppression using post-estimation commands. To test the robustness of these findings, we performed an inverse probability weighted analysis using the same propensity score model (Supplementary Materials) and a trimmed analysis (Supplementary Figure 1).

RESULTS

Demographics and Definition of the Active Clinic Cohort

Data from 1816 individuals was included in the analysis (Supplementary Figure 2). The median age was 51 years with an interquartile range (IQR) of 41–58, 12% (n = 221) were female sex at birth, 8% (144) were Asian, 18% (328) were Black, 26% (479) were Latinx, and 43% (779) were White (Table 1). At the beginning of SIP, 5% (85) were experiencing homelessness, 9% (155) were unstably housed, and 16% (282) had severe mental illness. The median most recent CD4+ T-cell count was 505 cells/mm^3 (IQR, 331–727), with 15% (267) of individuals having a CD4+ T-cell count <200 cells/mm^3. The mean VS was 83.4% (95% confidence interval [CI], 82.8%–85.2%) over the 2 years before SIP.

Multicomponent Strategy Reach

Clinic outreach successfully contacted 91% (1661) of the clinic cohort to proactively offer social services during the initial wave of attempts through June 2020 (Table 2). Following housing outreach, 79% (67) of PLWH experiencing homelessness and 24% (37) of those unstably housed received permanent housing or a SIP hotel room. Of the 240 PLWH experiencing homelessness or unstable housing, 38% (97) were part of the POP-UP program, with 10% (24) enrolled after SIP.

HIV Viral Load Outcomes

The adjusted odds of VS increased 1.34 fold following institution of the post-SIP multicomponent support strategies (adjusted odds ratio [AOR], 1.34; 95% CI, 1.21–1.46). PLWH who were in the POP-UP program at any point experienced 1.51-fold higher odds of VS (95% CI, 1.07–2.11). Among PLWH previously experiencing homelessness or unstable housing who received permanent housing or a SIP hotel room during the pandemic, the odds of VS increased 1.94 fold (95% CI, 1.05–3.59). In the ITS analysis, the rate of VS increased by 1.05 fold per month continuously following institution of the multicomponent strategies (AOR, 1.05; 95% CI, 1.01–1.08; Figure 1), increasing from 81.4% at the beginning of SIP to 89.8% at the end of the analysis.

Table 1. Demographics of the Clinic Sample and Those Lost to Follow-up

Demographic		Overall (N = 1816)
Age, median (IQR), years		51 (41–58)
Female sex at birth, n (%)		221 (12)
Race/ethnicity, n (%)		
Asian	144 (8)	
Black		323 (18)
Latinx		479 (26)
Mixed/Other		91 (5)
White		779 (43)
Housing status, n (%)		
Unhoused[a]	85 (5)	
Unstably housed[b]		155 (9)
Severe mental illness via *International Classification of Diseases, Tenth Revision, Clinical* Modification, codes, n (%)		282 (16)
CD4+ T-cell count, median (IQR; most recent), cell/mm^3		505 (331–727)
<200 cell/mm^3, n (%)		267 (15)

Abbreviation: IQR, interquartile range.

[a]Living on the street, in a vehicle, or within a shelter.

[b]Living temporarily with friends or family or in a stabilization room.

Table 2. Multicomponent Strategy Reach and Date of Component Initiation

Strategy	Date Initiated	Proportion Impacted, n (%)
Clinic outreach	23 March 2020	1661 (91)
Resumption of in-person visits	30 March 2020	1816 (100)
Programs for people experiencing housing insecurity or homelessness (n = 240)		
Permanent housing expansion	19 March 2020	36 (15)
Shelter-in-place hotel room	19 March 2020	68 (28)
POP-UP program[a]	Preexisting	73 (30)
POP-UP program[a] expansion	30 March 2020	24 (10)

[a]A low-barrier high-intensity drop-in program for people living with human immunodeficiency virus who are experiencing homelessness.

Predictors of Virologic Nonsuppression

After examining factors associated with virologic nonsuppression that changed significantly over time following COVID-19 SIP, we found that age <40 years was associated with a 2.1-fold higher odds of unsuppressed viral load in the 2 years prior to SIP (AOR, 2.11; 95% CI, 1.35–3.31), although this difference was no longer present in the post-SIP period (AOR, 1.30; 95% CI, .80–2.13; Table 3). Similarly, unstable housing or lack of housing was associated with 7.28-fold higher odds of virologic nonsuppression during the pre–COVID-19 SIP period (95% CI, 4.78–11.08), but this attenuated to an AOR of 3.35 during the post–COVID-19 SIP period (95% CI, 2.10–5.32).

HIV Viral Load Monitoring

The mean rate of viral load monitoring decreased by 15% after the institution of SIP, with partial recovery to prior levels (Supplementary Figure 3; incidence rate ratio [IRR], 0.85; 95% CI, .83–.88). Prior to COVID-19 SIP, there were 2.29 viral load assessments per person-year, which decreased to 1.83 viral load assessments per person-year. Among PLWH experiencing homelessness, the rate of viral load monitoring did not change significantly (IRR, 0.92; 95% CI, .82–1.02). Among youth, the rate of viral load monitoring decreased by 25% (IRR, 0.75; 95% CI, .66–.85).

LTFU

Without surveillance data or in-depth tracing, the rate of LTFU would have been calculated as 8.7 per 100 person-years (95% CI, 7.5–9.8). Following the SFDPH surveillance database match, 105 individuals had laboratory data outside of the clinic,

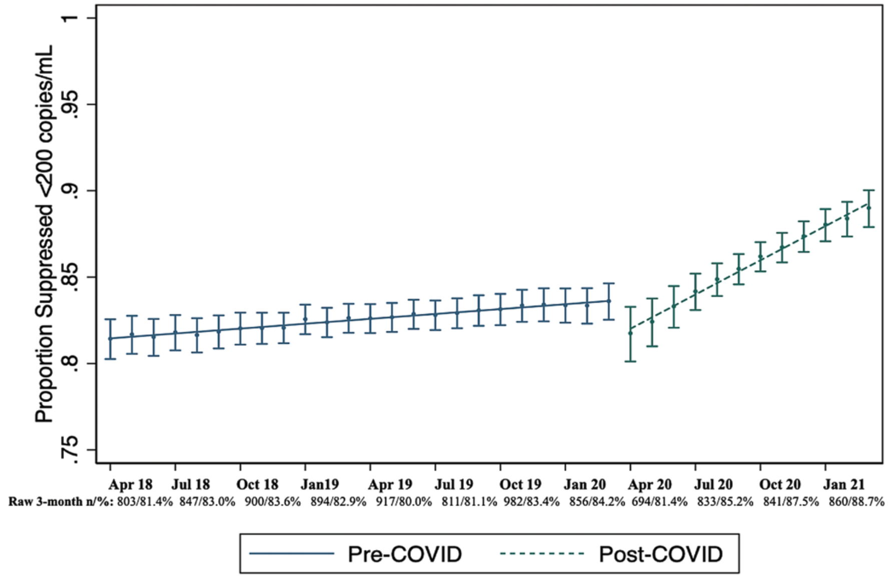

Figure 1. Mean human immunodeficiency virus virologic suppression (<200 copies/mL) per month before and after the shelter-in-place multicomponent support strategies via interrupted time series. The solid blue line demonstrates the trend of viral suppression from the adjusted mixed-effects model for the pre–COVID-19 period, with plotted points representing predicted means ±1 standard error. The green dotted lines and points represent the post–COVID-19 period. The raw virologic suppression number and percent are listed below the graph for each 3-month period. Abbreviation: COVID-19, coronavirus disease 2019.

of whom 81.9% (86) were virologically suppressed. Therefore, the rate of LTFU was recalculated to be 4.4 per 100 person-years

Table 3. Factors Associated With Unsuppressed Human Immunodeficiency Virus RNA >200 Copies/mL Over the Study Period: 1 April 2018–31 March 2021

Factor	Unsuppressed Human Immunodeficiency Virus RNA, Adjusted Odds Ratio; 95% Confidence Interval	*P* Value
Post-COVID-19 SIP	0.75; .68–.82	<.001
Age <40 years[a]	Over Pre-COVID-19 SIP period	
	2.11; 1.35–3.31	.001
	Over Post-COVID-19 SIP period	
	1.30; .80–2.13	.29
Male vs female sex at birth	1.13; .71–1.78	.61
Race/ethnicity vs White		
Asian	0.52; .28–1.01	.08
Black	1.52; .98–2.28	.08
Latinx	1.09; .79–1.56	.65
Mixed/Other	1.18; .59–2.33	.64
Unstable housing/experiencing homelessness vs housed[b]	Over Pre-COVID-19 SIP period	
	7.28; 4.78–11.08	<.001
	Over Post-COVID-19 SIP period	
	3.35; 2.10–5.32	<.001
Severe mental illness (*International Classification of Diseases, Tenth Revision, Clinical* Modification, codes)	0.97; .66–1.42	.86

Abbreviations: COVID-19, coronavirus disease 2019; SIP, shelter-in-place.

[a]Statistically significant change over time pre- and post-SIP (interaction *P* < .05 with the time interval indicator). For factors that did change during the SIP period, separate point estimates show the relationship for that factor over the pre–COVID-19 and the post–COVID-19 period, obtained using post-estimation commands.

[b]Living on the street, in a vehicle, shelter, temporarily with friends or family, or in a stabilization room.

(95% CI, 3.6–5.3). Following chart review/clinic-led tracing of the 109 remaining individuals, 11 were deceased, an additional 28 were in care elsewhere (133 total), 51 were known to be out of care, and 19 were unable to be contacted and no information was available from clinic data or tracing efforts (Figure 2). After active tracing, the cumulative 1-year LTFU rate (out of care or unknown status) was 2.8 per 100 person-years (95% CI, 2.2–3.5), and the mortality rate was 0.44 per 100 person-years (95% CI, .22–.79). If individuals known to be out of care were assumed to be virologically nonsuppressed and individuals with viral load data available via the surveillance match were included, VS at the end of the analysis period would decrease from 89.8% to 87.7%, but the increase would remain statistically significant (*P* < .001).

Predictors of LTFU Following Tracing and Surveillance Match

Older individuals had lower odds of LTFU, with 21% lower odds of LTFU for each 10-year increase in age (AOR, 0.79; 95% CI, .63–.98). Sex at birth, race/ethnicity, housing status, and unsuppressed viral load >200 copies/mL were not associated with LTFU (Table 4).

Scheduled and Attended Visits Before and After SIP

Before SIP, the mean number of scheduled visits per person-year was 7.03 (95% CI, 6.95–7.11), while the number of attended visits was 3.63 per person-year (95% CI, 3.56–3.69; Supplementary Figure 4). Following SIP, scheduled visits (including telephone visits) decreased by 9.1% (95% CI, .89–.93), with the mean decreasing to 6.41 per person-year (95%

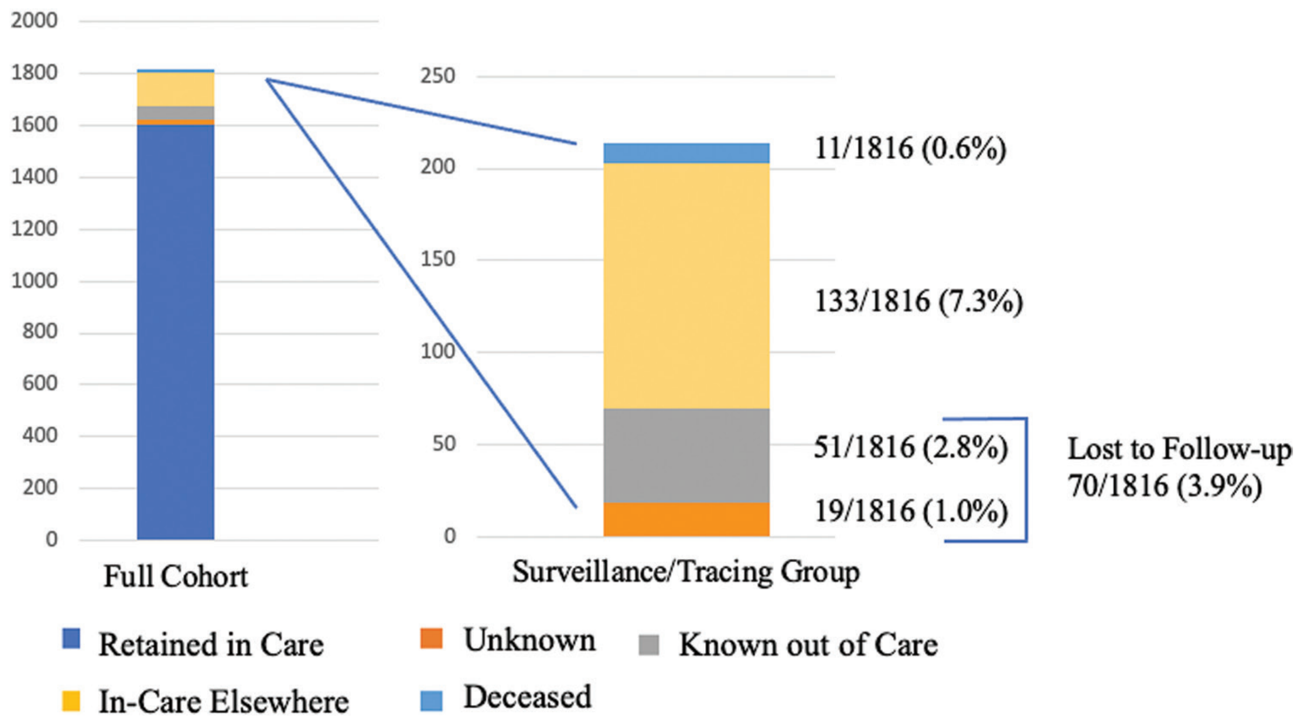

Figure 2. Retention in care outcomes following surveillance match and clinic tracing.

CI, 6.31–6.51). Attended visits (including telephone visits) decreased by 14.7% (95% CI, .83–.88) to a mean of 3.10 per person-year. The median number of days between visits was 62 pre-SIP (IQR, 29–98) and 63 post-SIP (IQR, 28–112). No known cases of COVID-19 were traced to contact within the clinic, either among staff or patients.

The proportion of attended telephone (nonvideo) visits to total attended visits was 64.9% in April 2020, the first full month when they were first offered as billable visits, and decreased to a minimum of 10.1% at the end of the analysis period ($P < .001$; Figure 3). Predictors of attending a telephone visit after SIP included having a suppressed viral load (adjusted rate ratio [ARR], 1.65; 95% CI, 1.33–2.03), while being non-White was associated with a decreased rate of telephone visit attendance (ARR, 0.77; 95% CI, .68–.86), as was experiencing homelessness/unstable housing (ARR, 0.50; 95% CI, .40–.61).

Propensity Score Sensitivity Analysis

In the alternate modeling strategy using propensity scores, the association between the post-SIP period and higher VS changed minimally (AOR, 1.30; 95% CI, 1.16–1.45). The inverse probability weighted analysis yielded results similar to those of the other 2 strategies (AOR, 1.31; 95% CI, 1.17–1.46).

DISCUSSION

After an initial destabilization after COVID-19 SIP orders [18], VS rates in a large municipal safety-net clinic increased more rapidly than in the previous 2 years following the institution of multicomponent strategies to support the health of PLWH following COVID-19 SIP. Furthermore, disparities among PLWH experiencing homelessness/unstable housing and young PLWH narrowed over this time period. The sustained increase in VS rates and decrease in disparities by housing status at the Ward

Table 4. Factors Associated With Loss to Follow-up After Coronavirus Disease 2019 Shelter-in-Place Order

Factor	Loss to Follow-up; Adjusted Odds Ratio; 95% Confidence Interval	*P* Value
Age per 10 years	0.79; .63–.98	.03
Male vs female sex at birth	1.09; .51–2.32	.82
Race/ethnicity vs White		
Asian	0.94; .35–2.50	.91
Black	1.10; .56–2.16	.78
Latinx	1.16; .65–2.07	.62
Unstable housing or experiencing homelessness[a]	1.28; .66–3.22	.42
Unsuppressed human immunodeficiency virus RNA >200 copies/mL	1.18; .68–2.06	.56

[a]Living on the street, in a vehicle, shelter, temporarily with friends or family, or in a stabilization room.

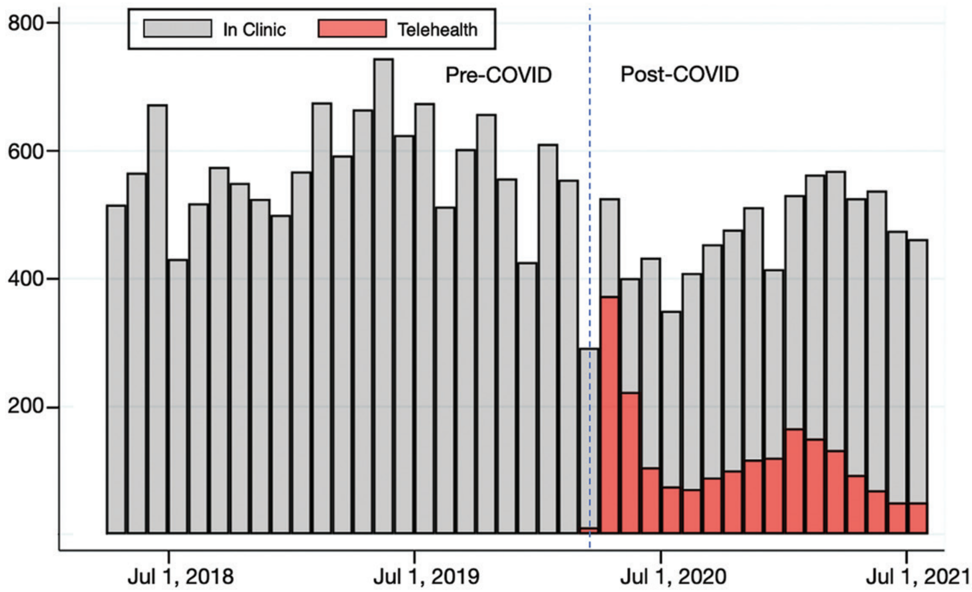

Figure 3. Attended in-person vs telephone visits per month before and after the shelter-in-place order. Abbreviation: COVID-19, coronavirus disease 2019.

86 HIV Clinic are notable given decreased VS citywide in 2020, with VS rates among homeless PLWH decreasing from 39% to 20% in San Francisco [17]. Furthermore, the LTFU rate remained similar or lower compared with prior years after active tracing and a surveillance match were performed [23]. Although the number of viral load assessments and attended visits decreased dramatically after SIP, there was partial recovery thereafter. Telephone visits, while initially accounting for the majority of attended visits in April 2020 at Ward 86, decreased to 10% of attended visits by the end of the analysis period, echoing analyses elsewhere [12].

Potential differential impacts of the multicomponent strategies on young PLWH may be related to added convenience of a telemedicine option for HIV care delivery. In a prior analysis, we found that young PLWH had fewer no-shows immediately after the institution of telemedicine [18], as has been seen in an analysis among PLWH receiving video visits in Seattle, Washington, during COVID-19 [12]. Alternatively, given greater LTFU among young individuals, it is possible that certain young PLWH did not present for follow-up assessments, and this was incompletely adjusted for in models.

Programs targeted toward PLWH experiencing homelessness, including housing within SIP hotels [20], and expansion of housing outreach support in concert with a preexisting multicomponent program for people with unstable housing and virologic nonsuppression (the Ward 86 POP-UP program [6]), likely contributed to the narrowing of disparities among homeless PLWH. Housing status is a strong predictor of VS and future mortality among PLWH [24–26], with housing interventions shown to improve disparities [25, 27]. Among individuals who received permanent housing or housing within a SIP hotel, VS increased most dramatically. Anecdotally, some patients initiated antiretroviral therapy for the first time in their lives as a result. San Francisco plans to extend SIP hotels through September 2022 and has committed to providing offers of permanent housing to individuals currently staying in SIP hotels. Increases in supportive housing [28] and targeted programs that seek to meet the unique needs of housing-insecure PLWH, including outreach, in-person drop-in availability, and incentives [29], will likely be needed to make further gains.

Although telemedicine had high uptake initially, its use declined significantly to 10% at the end of the analysis period. Although telemedicine provides an important care option for PLWH not impacted by the digital divide, it could have limited impact on narrowing disparities among some underserved populations without additional cointerventions, such as provision of phones, computers, internet access, and private spaces, as well as technological literacy interventions [19]. Additional research is needed to understand the populations for whom telemedicine is beneficial, particularly given that non-White, unstably housed, and unsuppressed PLWH had a lower rate of telephone visit attendance. The risks of in-person visits should be balanced against the importance of providing continued access to clinic medical services and social services to underserved populations.

Although initial calculations suggested a high LTFU rate, a public health surveillance database match and active tracing resulted in a LTFU rate of approximately 3 per 100 person-years, similar to or lower than those found in prior analyses [23]. Future analyses should acknowledge that LTFU estimates using internal administrative data are likely overestimates, although active tracing is time-consuming and surveillance databases may not be available in all jurisdictions. Proactive outreach may also have contributed to a relatively low LTFU rate.

There are several limitations to this analysis. As there was no contemporaneous control group or randomization, continuous improvements in VS could be related to outside factors, such as fear of greater susceptibility to COVID-19 motivating better medication adherence and other health behaviors [30]. Although the rate of virologic monitoring was somewhat lower in the post-SIP period among the entire patient population, we sought to account for this using maximum likelihood estimation approaches, which account for missingness in the outcome in a similar fashion to multiple imputation [31]. Furthermore, there was no difference in the rate of virologic monitoring among PLWH experiencing homelessness or unstable housing over time, the subgroup with the greatest gains in VS. Given that VS and the rate of virologic monitoring decreased citywide during this time period, with worsening disparities by housing status, the improvement in VS in this large safety-net clinic is unlikely to be related solely to secular trends [17]. We sought to address potential confounding by using various methods, with qualitatively similar results obtained by pre- and post-inverse probability weighting and ITS analyses. However, it remains possible that residual, unmeasured confounding impacted these findings, particularly given that we were limited to predominantly electronic medical record–measured covariates. The post–COVID-19 time period examined is relatively short, so it is possible that gains may plateau at later time points. The electronic medical record also did not provide information on gender identity, limiting the ability to explore impacts on transgender populations. Although subgroups were explored, we cannot definitively identify mechanisms of the multicomponent strategies' impact or which components were particularly impactful. Qualitative research is planned to further explore the mechanisms of these findings.

In conclusion, despite initial declines in VS at a large municipal HIV clinic following COVID-19 SIP [18], institution of multicomponent support strategies that included proactive outreach for linkage to social services, maintenance of in-person visits, availability of drop-in care while maintaining telemedicine access, and programs targeted toward the needs of unstably housed PLWH was associated with sustained increases in VS. This increase continued for more than a year following the onset of the multicomponent support strategies at the clinic, despite concomitant decreases in VS citywide. Expansion of telemedicine and housing resources and promotion of social services via proactive outreach, while maintaining full access to in-person services, are needed to support HIV outcomes among underserved populations during the COVID-19 pandemic.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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