Examination of Associations Between Zip Code Level COVID-19 Case Rates and Mental Health in Washington Counties among Young Adults

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Abstract

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Background: Young adults have shown elevated levels of depressive and anxiety symptoms during the pandemic. However, few studies which have examined the impact of the COVID-19 pandemic on mental health have used area level COVID-19 case rates over time as a possible predictor for adverse outcomes. **Method:** The study sample included 382 participants residing in King, Snohomish, or Pierce County in zip codes with non-zero population counts, originally recruited from Project Transitions, a longitudinal study of young adults. Six bi-monthly surveys conducted from September/October 2020 through July/August 2021 used an 8-item measure for depressive symptoms, a 7-item measure for anxiety symptoms and a 12-item measure of flourishing. COVID-19 case rates were derived from positive cases per zip code from King, Pierce, and Snohomish Counties divided by estimated populations per zip code. Fixed effects models specifying a negative binomial or Gaussian distribution for the outcome were used to examine within-person associations between zip code COVID-19 prior month case rates per 1000

persons and mental health outcomes. Effect modification by sexual minority identity as well as by a dichotomized variable for financial strain was assessed using interaction terms.

Results: For any given person occupying the same zip code, rate ratios for the PHQ-8 and GAD -7 score showed no association with zip code case rates (RR for PHQ-8 outcome = 1.00; 95% CI: -0.97, 2.97; and RR for GAD-7 outcome = 1.00; 95% CI: -0.97, 2.97). There was also no statistically significant association between zip code case rates and flourishing ($\beta = 0.06$; 95% CI: -0.12, 0.25). The association between zip code case rate and flourishing appeared to differ according to sexual identity, such that there was a negative association among those identifying as a sexual minority and a positive association among those not identifying as a sexual minority (interaction-p = 0.041).

Conclusion: This study did not show associations between zip code level case rate and the mental health outcomes. However, secondary analyses suggest that the association between zip code case rates and flourishing was modified by sexual minority status. Addressing population wide inequities in mental health requires additional multilevel research to understand upstream drivers.

Introduction

Young adults during the pandemic have shown elevated levels of depressive and anxiety symptoms.[1] This is concerning because this age group also displayed a pre-pandemic decade-long trend of increased prevalence of depression and anxiety disorders.[2] Young adults are vulnerable to adverse social, financial, and educational circumstances, the consequences of which may adversely affect life trajectories into later adulthood.[3,4] Because the ongoing pandemic led to significant disruptions across many aspects of typical day-to-day functioning, including job loss and limited socializing, additional research is needed to understand factors contributing to young adult mental health functioning.[5,6]

The localized prevalence of COVID-19 may be important in affecting mental health. Disaster research and community resiliency work has primarily relied on examining neighborhood-level effects resulting in different mental health outcomes. Small areas will often experience disasters uniquely and community closeness is associated with being protective against poor mental health outcomes.[7–10] During the pandemic, between-county differences in case rates are observed to be associated with systemic socio-economic inequity, structural racism, and absences in medical care, especially among underserved populations.[11–13] As a result of higher inequity, some populations may be at even higher risk for both higher rates of COVID-19 and for worse mental health outcomes. Using repeated COVID-19 case rates at the zip-code level as a predictor for mental health outcomes may reflect these localized changes and effects.

While many studies have examined depressive and anxiety symptoms during the pandemic, less work has considered the role of flourishing. Flourishing measures have been recently developed and use of such measures has been expanding to examine aspects of positive mental health and overall well-being.[14,15] Flourishing measures attempt to holistically capture a person's complete satisfaction across multiple domains to describe the individual's state of being. The research examining associations between case rates and well-being has been limited. Thus, there is a need to understand within-person changes in overall well-being as a result of zip code level case rate.

Studies suggest that sexual minority populations have fared worse in regard to mental health during the pandemic than those who are not in this group, which is consistent with minority stress theory.[16–20] Similarly, those who face higher financial strain may also fare worse compared to those who are more financially comfortable, likely also due to worsening inequities and poor access to resources and support systems.[21–23] Examining each of these characteristics as modifiers of the association of interest is important to uncover how higher local case rates may exacerbate existing mental health inequities over time.

This study's primary aim is to examine zip-code level COVID-19 case rates and with depressive symptoms, anxiety symptoms and flourishing among young adults living in the Greater Seattle

metropolitan region over the course of one year during the pandemic. Moreover, this study explored whether associations differed according to sexual identity and self-rated pre-pandemic financial strain. We hypothesized that an increase in case rates in a person's zip code would be associated with a within-person increase of depressive and anxiety symptoms and decreased flourishing. As secondary analyses, we explored effect modification by sexual identity and financial strain. We anticipated that for those who identify in a sexual minority population, an increase in case rates would be associated with greater increases in depressive and anxiety symptoms, and greater decreases in flourishing as compared to those who do not identify in a sexual minority population. We also hypothesized that an increase in case rates for those facing pre-pandemic high financial strain would be associated with greater increases in depressive and anxiety symptoms, and a greater decrease in flourishing compared to those who faced low strain.

Methods

Study sample

The current study uses longitudinal data from Project Transitions to assess mental health symptoms. Data were collected in six bi-monthly follow-ups from September/October 2020 through July/August 2021.

The original Project Transitions study was intended to understand associations between young adult social role transitions and alcohol use. The study enrolled a community sample of 767 young adults on a rolling basis between February 2015 and January 2016. Participants were recruited through online and print media ads, flyers, word of mouth, and local community agencies. Inclusion criteria in the original study included the following: age between 18-23 years old at screening (in 2015/2016), residency within the Seattle metropolitan area, access to an email address, alcohol consumption at least once in the previous year, and ability to go to an office location for consenting, identity/age verification and baseline assessment.

In order to understand potential impacts of the pandemic in the sample, the project received funding to conduct additional study assessments in the sample. Participants were surveyed bi-monthly over the aforementioned 12-month period. Half were randomized to begin the surveys in September 2020 and the other half began in October 2020. From the original cohort, 566 adults opted in for this supplemental study. For this analysis, only those who had ever lived in King, Snohomish, or Pierce County during the pandemic study period were included.

Measures

Independent Variable

Zip-code COVID-19 case rates were calculated from county case counts over time and population estimates. Estimates of positive cases per zip code were publicly available as daily positive counts from the King County website. Public health contacts from Snohomish and Pierce County provided case counts per zip code for each respective county. Daily rates were summated to equal estimated cases per month. County sources additionally excluded some zip

code positivity in Snohomish and Pierce County due to small numbers and possible identifiability. Case counts in overlapping zip codes reported in different counties were summated.

Total population estimates per zip code came from the Washington State Office of Financial Management, Small Area Estimate Program. The estimations are approximate for 2021 and the Office derived population values from the 2010 census.[24]

The primary independent variable was calculated to be the estimated number of cases per month divided by the estimated total population per zip code times 1000 persons.

Outcomes

Three different mental health outcomes are used for this study: depressive symptoms as measured using the 8-item Patient Health Questionnaire (PHQ-8),[25] anxiety symptoms as measured by the 7- item Generalized Anxiety Disorder measure (GAD-7),[26] and the flourishing as measured by the 12-item Flourishing measure.[15] The PHQ-8 consists of the same items as the PHQ-9, except that it excluded the item assessing suicidal ideation and self-harm.

The PHQ-8 and GAD-7 response options ranged from 0 = "Not at all" to 3 = "Nearly Every Day" with items asking about either depressive and anxiety symptoms, respectively, occurring in the past two weeks. For the PHQ-8, Cronbach's α ranged between 0.90 and 0.92 in the bi-monthly longitudinal surveys. Each item's scores are totaled for this survey and yield a single score ranging from 0 to 24. Cronbach's α for the GAD-7 ranged between 0.91 and 0.94 and the scores are totaled for a range of 0 to 21. For each measure, a lower score indicates minimal symptoms, and a high score indicates severe symptoms.

The items of the Flourishing measure aim to capture well-being across the following domains: happiness and life satisfaction, mental and physical health, meaning and purpose, character virtue, close social relationships, and financial and material security. The Flourishing measure response options ranged from 0 - 10 with 10 indicating the highest level or frequency of the item. Participants can select a value they feel most represents their level of well-being. With two questions per domain, the total score for this measure ranges from 0 – 120 with a high score indicating positive or fulfilled well-being. Cronbach's α for this measure ranged between 0.90 and 0.93.

Covariates of Interest

Two additional variables were in this study for effect modification analyses. First, a dichotomous variable was created from the question "What is your sexual orientation?" indicating a participant who, at any point over the course of the COVID-19 survey, identified in a sexual minority group (Bisexual, Gay, Lesbian, Queer, Questioning or Other) or not (Straight/ Heterosexual).

For the second analysis, an additional dichotomous variable is derived from the question “In the 3 months before the COVID-19 outbreak, how well would you say you personally were managing financially?” which identified those of low prior-pandemic financial strain (“Living comfortably”) or high financial strain (“Doing all right”; “Just about getting by”; “Finding it quite difficult”; and “Finding it very difficult'). Dichotomization of the financial strain variable was used to achieve similar sizes in both groups. Examination of baseline averages of the PHQ-8, GAD-7, and Flourishing scores according to this dichotomous financial variable showed notable differences between the two groups.

Statistical analysis

Fixed effects models were used to examine the within-person associations between zip code COVID-19 prior month case rates per 1000 persons and depressive and anxiety symptoms, and flourishing, based on measure scores. This model included fixed parameters for zip code COVID-19 case rates as well as fixed parameters for the zip code of residence, individual, and the study month. By including these parameters, the model adjusts for time and time-fixed place and person specific contextual influences. Thus, the parameter for zip code case rate should represent the within-person association between zip-code level case rate and the mental health score outcome, independent of time trends and any time-fixed factors at the zip code and individual levels.

Each symptom measure was included as the outcome in separate models. The PHQ-8 and GAD-7 yield count scores, which are discrete, non-negative variables and these measures tend to have positive skewness. Due to evidence of overdispersion, a negative binomial distribution was specified rather than Poisson. Exponentiating the coefficients allows estimation of Rate Ratios (or Count Ratios) that describe the proportional change in the outcome within the same person for an increase in 1 case per 1000 persons in the zip code of residence. Based on evaluation of residual diagnostics, a linear regression model appeared to be appropriate for models with flourishing as the outcome.

For the effect modification analyses, an interaction term was included in addition to the main model, testing a possible interaction with the zip code level case rates and the effect modifier of interest. Thus, six additional models were specified for testing the two possible modifiers on the outcome variables of interest. For the PHQ-8 interaction model, small population size for the low financial strain group led to error in model fitting and the parameter for zip code was excluded for this analysis.

All statistical analyses were run using R version 4.1.6.[27] The “MASS” package was used to run the negative binomial models.[28]

Results

Of the study sample, 382 subjects had ever lived in King, Snohomish, or Pierce County in zip codes with non-zero population counts (excluding those with PO box zip codes) over the duration of the study period and answered the PHQ-8, GAD-7 and Flourishing measure. Of these 382 respondents, 289 (76%) lived in King County, 56 (9%) in Snohomish County, and 37 (15%) in Pierce County. Sixty-four percent of respondents identified as Female, 51% of the population identified as Caucasian or White, 31% of the population ever identified as a sexual minority over the course of the study period, and 36% reported low pre-pandemic financial strain (Table 1).

Main Analysis

Based on results from the fixed effect models, there was no strong evidence that zip code COVID-19 case rates were associated with mental health outcomes (Table 2). For any given person occupying the same zip code, rate ratios for the PHQ-8 and GAD -7 score showed no association with zip code case rates (RR for PHQ-8 outcome = 1.00; 95% CI: -0.97, 2.97; and RR for GAD-7 outcome = 1.00; 95% CI: -0.97, 2.97). There was also no statistically significant association between zip code case rates and flourishing ($\beta = 0.06$; 95% CI: -0.12, 0.25).

Effect Modification Analyses

Preliminary Analysis

In examining whether the association between case rate per zip code and the three mental health measures varied by sexual minority status or high financial strain, an initial analysis was completed to examine the difference in average PHQ8, GAD7, and flourishing score over time. Those who identified as a sexual minority compared to those who did not showed higher baseline depressive symptom (8.42 vs 6.12, $p < 0.001$) and anxiety symptom scores (6.91 vs 5.1, $p < 0.001$), in addition to lower flourishing scores (55.84 vs 60.88, $p = .002$).

For those who reported high pre-pandemic financial strain compared to those with low strain, the baseline average in depressive (7.53 vs 5.93, $p < 0.001$) and anxiety symptoms (6.22 vs 4.86, $p < 0.001$) was significantly higher. Flourishing for the high financial strain group was significantly lower compared to those who reported experiencing low financial strain (56.24 vs 63.15, $p < 0.001$).

Interaction and Stratified Analysis

When examining statistical interactions as a test of effect modification, there was one statistically significant finding. The association between zip code case rate and flourishing appeared to differ according to sexual identity (interaction-p = 0.041) (Table 3). To aid in interpretation, when stratifying by sexual identity, those who identify as a sexual minority showed a negative association between zip code case rate and flourishing ($\beta = -0.165$), while those who do not identify in this group showed a positive association ($\beta = 0.165$).

Due to the concerns related to low statistical power, further exploration of effect modification was done by examining stratified models. Results from stratified models were consistent with interaction analyses (Supplemental Table 1). For the depressive and anxiety models, rate ratios for zip code level case rate when stratifying by sexual minority status were similar and all close to 1 (range: 0.993, 1.009) (Supplemental Table 1). For the flourishing models, while stratifying by financial strain, the high financial strain case rate estimate is -0.010 while the low financial strain is 0.153. The difference between the estimates is pronounced, but the interaction model was not statistically significant ($p = 0.141$).

Discussion

This study examined associations of zip code COVID-19 case rates with depression, anxiety and flourishing from September 2020 to August 2021. Over the year, several waves were observable with changing case load and burden in the three counties of interest, King, Snohomish, and Pierce County. In this study of young people, zip-code COVID-19 case rates were not statistically significantly associated with mental health outcomes. However, some evidence suggested that the association between zip-code level COVID-19 case rates and lower flourishing varied by sexual identity such that a stronger negative association was observed among those who identified as a sexual minority compared to those who did not.

The main analysis of this study did not detect a significant association between zip code level case rate and the mental health measures of interest. This is in line with the limited prior research that exists, which examined prefecture-level case numbers in Japan and severe psychological distress.[29] To the best of our knowledge, no other studies have examined zip-code level case rates and repeated mental health outcomes. Additional small area level research with larger sample sizes, and national or multi-state coverage is needed to better understand if an association may exist. In other research, case rates are intertwined with local level lockdown policies and general disruption in day to day living.[30,31] These effects of these more proximal pandemic-related factors have been observed to have strong associations with poor mental health outcomes.[32–35] The direction of association between area level case rates and mental health is further complicated by the fact that the conditions which may lead to poorer mental health outcomes may also be associated with higher COVID-19 case rate.[36] Addressing population wide inequities in mental health ultimately requires additional multilevel research to understand upstream drivers.

This study provides evidence that the association between zip code case rates and lower flourishing is stronger for sexual minority compared to non-minority individuals. In general, sexual minority groups have experienced greater psychological impact over the course of the pandemic, reporting substantially higher levels of depression, anxiety, substance use, stress and poor coping which may be due to heightened pre-existing vulnerabilities in this population.[16–20]

This study provides additional information suggesting higher case rates in a person's zip code could be related to overall worsening levels of flourishing. This finding is consistent with previous work investigating minority stress during the pandemic. In general, worse mental health has been observed during the pandemic for persons with minoritized racial/ethnic or sexual identity, who are women-identifying, and with lower socio-economic stability.[19,37–39] Groups that are already facing systemic hardship may have a more difficult time adjusting or coping with the effects from the pandemic. Additional research is needed to better understand the extent of mental health impact of the pandemic for other minority populations, including those of minority racial/ethnic and gender identities.

Limitations

There are a number of limitations that should be considered. Due to the sampling methodology of the original Project Transitions and the subsequent COVID-19 cohort, this population may not be representative of the general young adult population of King, Snohomish, and Pierce County. For the predictor of interest, population count, and case count may be subject to error. For areas of 1,000 persons or higher, error may be from 5% to 15% and possibly even higher among smaller areas.[24] Moreover, due to the size of the study sample, effect modification analyses may be underpowered. However, examinations of stratified models are consistent with statistical tests of interaction.

Conclusion

In this study of young adults living in three counties in Washington State, zip-code level COVID-19 case rates were not associated with depressive symptoms, anxiety symptoms, or flourishing in the full sample. The pathways through which area-level case rates could yield impacts on mental health over time are likely complex. While local case rates alone may not be as related to a single person's depression, anxiety, or flourishing, addressing broader systemic issues that may result in gaps in mental health may be more relevant. That sexual minority groups were shown from this study to have lower levels of flourishing as case rates increased may be reflective of systemic differences in social support and access to resources, which are shown to be protective factors for mental well-being. More research with larger and more representative study samples may be necessary to better understand the ways in which local case rates may differentially impact mental health.

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Figure 1: Mean Mental Health Scores over Time per County

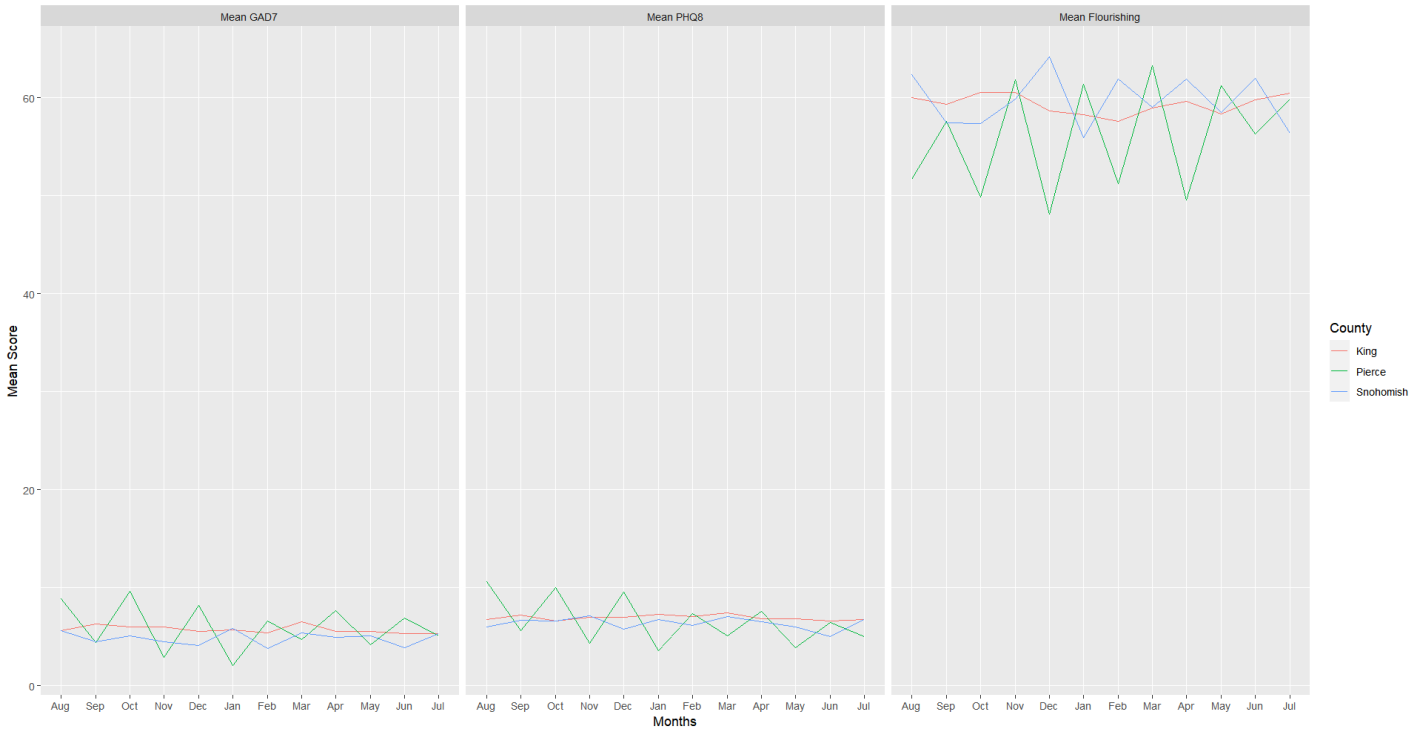

Table 1: Participant Descriptive Statistics at first participant Inclusion (N = 382)

Characteristic at first participant inclusion		**N = 382[1]**
County of Residence		
	King	289 (75%)
	Pierce	37(9%)
	Snohomish	56 (15%)
Age		
	22 - 24	165 (43%)
	25 - 27	119 (31%)
	28 - 30	98 (27%)
Ever identified in an LGBTQ minority group		
	Yes	119 (31%)
	No	252 (66%)
	NA's	11 (3%)
Sex		
	Female	245 (64%)
	Male	137 (36%)
In the 3 months before the COVID-19 outbreak, how well would you say you personally were managing financially?		
	Living Comfortably	138 (36%)
	Doing all right/ Just about getting by/ Finding it quite difficult/ finding it very difficult	206 (54%)
	NA's	38 (10%)
Hispanic/Latinx population		29 (8%)
	None	353 (92%)
Reported Race/Ethnicity		
	Asian or South Asian	87 (23%)
	Black or African American	22 (5.8%)
	Caucasian or White Non-Hispanic/Latinx	195 (51%)

	American Indian or Alaskan Native	6 (1.6%)
	Arab, Middle Eastern or North African	5 (1.3%)
	More than one race	42 (11%)
	Other	8 (2.1%)
	NA's	12 (3%)

[1]: Percentages are rounded and may not summate to 100

Table 2: Estimates and 95% CI between Case Rate per 1000 persons and Mental Health Outcomes

Model Estimates			
	PHQ-8	GAD-7	Flourishing
	Count Ratio	Count Ratio	β
Case Rate per 1000 persons	1.002 (-0.966, 2.969)	0.997 (-0.973, 2.967)	0.064 (-0.121, 0.249)
Month Effect	0.993 (-0.923, 2.959)	0.989 (-0.981, 2.959)	0.039 (-0.095, 0.175)

Table 3: Results of Interaction Model Estimates and P-values

		PHQ-8	GAD-7	Flourishing
		Count Ratio	Count Ratio	β
Sexual Minority Interaction				
	Case Rate per 1000 Persons	0.996 (p = 0.488)	0.999 (p = 0.985)	0.185 (p = 0.096)
	Sexual Minority Status	12.809 (p < 0.001)*	4.008 (p = 0.121)	-14.041 (p = 0.071)
	Case Rate x Sexual Minority Interaction	1.014 (p = 0.099)	0.992 (p = 0.423)	-0.422 (p = 0.041)*
Financial Strain Interaction				
	Case Rate per 1000 Persons	1.003 (p = 0.489)	1.000 (p = 0.945)	0.0003 (p = 0.998)
	Financial Strain	0.846 (p = 0.347)	1.235 (p = 0.324)	-15.069 (p = 0.005)*
	Case Rate x Financial Strain Interaction	0.995 (p = 0.532)	0.990 (p = 0.335)	0.149 (p = 0.429)

* Significant result

Figure 2: Predicted Trends of Flourishing Score by Zip Code Case Rate and Sexual Minority Status

Supplemental Table: Stratified Model Estimates

Model Estimates			
	PHQ-8	GAD-7	Flourishing
	Count Ratio (95% CI)	Count Ratio (95% CI)	β (95% CI)
Sexual identity			
Sexual Minority	1.009 (-0.963, 2.981)	0.993 (-0.983, 2.969)	-0.165 (-0.529, 0.198)
Non-Sexual Minority	0.998 (-0.972, 2.968)	0.999 (-0.973, 2.971)	0.165 (-0.044, 0.375)
Pre-pandemic Financial Strain			
High Financial Strain	1.002 (p = 0.661)^	0.989 (-0.987, 2.964)	0.153 (-0.132, 0.438)
Low Financial Strain	1.003 (p = 0.517)^	1.003 (-0.969, 2.975)	-0.010 (-0.266, 0.246)

^result excludes zip code parameter in model