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Cumulative Exposure to Police-Involved Shootings and Mental Health Conditions in Minneapolis, Minnesota

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Abstract Exposure to lethal or non-lethal police-involved shootings within communities has been shown to negatively impact individual mental health. Most literature has found this association through survey data that cannot speak to contemporaneous and cumulative impacts of police shootings. Given heterogeneity in both policing and community characteristics, immediate and granular mental health outcomes related to police-involved shootings must be explored. Our study examines how temporal community-level exposure to police shootings influences rates of mental health condition diagnosis at the ZCTA (ZIP code tabulation area) and month level using hospital discharge data from Minneapolis, Minnesota. For our exposures, we created a cumulative counter of police-involved shootings within ZCTAs and a lagged exposure indicator of police-involved shootings in the previous month. Using two-way fixed effect panel models, we find a nonlinear relationship between cumulative shooting exposure and rate of mental health diagnosis. As cumulative shootings increase, their effect on overall mental health diagnosis rate in Minneapolis increases until reaching a peak and then diminishes. This trend is similar across racial groups. This may be due to sensitization (increases in response to a certain point) and desensitization (diminishing responses after that point) as police shootings accumulate. In contrast, the effect of recent shooting exposures is null and weak, suggesting that it is the initial compounding, concentrated nature of police violence that exacts the greatest toll on community mental health. Findings highlight the need to investigate temporal exposure to police violence at granular levels to further understand its negative mental health impacts on community health.

Keywords Police violence · Police shootings · Mental health · Cumulative exposure · Minneapolis

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Introduction

Police violence, which encompasses any kind of physical or psychological injury caused by law enforcement, is a pervasive public health issue [1]. A severe form of police violence is officer-involved shootings, which injure or kill over 1700 people in the United States annually and 55% of those shot

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dying from their injuries [2]. Police shooting victimization burdens certain subpopulations more than others — 52 of every 100,000 men and boys in the United States will be killed by police, compared to 3 out of every 100,000 women and girls [3]. And, those with racial, ethnic, or sexual minority status are more likely to be stopped by police [4] and more likely to be threatened, abused, or shot by them [3].

Like direct exposure to police violence [1, 5–8], indirect exposure to police violence has negative mental health effects on communities. The mechanism behind poorer mental health outcomes following exposure to police violence is theorized to stem from the deep psychological harm induced by pervasive state-sanctioned violence, limited options for recourse, disrupted feelings of safety, along with the reinforcement of racial hierarchies [9]. Studies have found that witnessing police violence and living in areas with higher levels of police abuse, like racially disparate stop-and-frisk practices, are associated with increased hypervigilance and psychological distress [10, 11]. Disproportionate exposure to police violence increases mental health risks among Black individuals especially [10, 11]. Poor mental health outcomes are observed among Black individuals when images of Black fatal police shootings are broadcasted nationally, with reports of trauma, constant fear of dying, and hyper-alertness [12, 13]. The vicarious exposure impacts can also be seen at the city-level. Santaularia et al. (2024) observed increases in Black mental health emergency room diagnoses in the months following the murder of Mr. George Floyd in Minneapolis, Minnesota [14].

Studies have found that *repeated* exposure may further intensify these impacts on mental health. Each additional police violence exposure "dose" is found to have compounding negative mental health effects on LGBQ Black youth using survey data [15]. This suggests that exposure to additional police shootings may have a cumulative negative impact on mental health as police violence exposure increases. A quasi-experimental study also using survey data found that each additional police killing of unarmed Black Americans in the three months prior to the survey interview was associated with an increase of 0.14 poor mental health days among Black respondents but not among White respondents, with the largest effect being one to two months after exposure [16].

While studies underscore the negative impact of police violence exposure on community mental health, gaps remain about how mental health diagnosis rates respond to the repeated trauma of police shootings. Current literature has focused on the impact of fatal police-involved shootings on mental health at the state or county level, without considering the cumulative, or compounding, exposure to police shootings over time at lower levels of geography. We theorize that the accumulation of police shootings in ZCTAs can lead to increased stress on communities, resulting in greater stress on mental health, which may result in individuals seeking professional mental health care. Given local heterogeneity in policing levels and practices as well as community characteristics *within* states and counties, immediate and granular mental health diagnoses related to officer-involved shootings must be explored. Most extant studies have relied upon cross-sectional survey data, rather than longitudinal data that are better suited to capturing the dynamic relationship between police violence and mental health diagnoses. Scholarship to date has yet to directly compare the influence of varying temporal exposures of police violence within the same study sample.

We examine how temporal exposure to police shootings influences rates of mental health diagnosis in Minneapolis, Minnesota using a uniquely constructed Zip Code Tabulation Area (ZCTA)-month panel dataset merging various sources of administrative health and social data. Our study builds on prior literature by operationalizing exposure to police-involved shootings with two different temporal windows: a cumulative sum aggregating all shootings over time within each ZCTA, beginning at zero on January 1, 2016, and continuing through December 31, 2020 and a binary lagged variable capturing shooting exposure in the prior month during the same period. These measures allow us to explore cumulative and immediate effects on community-level mental health. The study location, Minneapolis, has long-standing spatial and racialized inequities, including in housing, exposure to violence, and police contact patterns [17]. The Minneapolis-Saint Paul metropolitan area is unique due to highly publicized police killings which sparked national police reform movements, including those of Philando Castile and George

Floyd. Such reactions may indicate increased treatment response to police violence by the Minneapolis study population. We explore racial heterogeneity of the temporal exposure effects, examining mental health across Black, Latine, and White subgroups.

Methods

Panel Data

We constructed a ZCTA-month panel dataset merging spatio-temporally located data from the Minnesota Hospital Association, the Minneapolis Police Department, and the American Community Survey. This panel covers the entire population living in Minneapolis, Minnesota between January 2016 through December 2020. We use the Census Bureau's TIGER/Line ZCTA shapefiles to define the spatial boundaries for each ZCTA contiguous with the Minneapolis city boundaries. Our panel consists of 22 ZCTAs for 5 years for a total of 1320 observations.

Outcome

We examine inpatient and outpatient data from 2016 to 2020 Minnesota Hospital Association's administrative discharge data using International Classification of Diseases (ICD)−10 codes F01-F99 to measure mental health diagnoses [18]. The outcome is the rate of mental health diagnoses per 1000 people in each ZCTA-month with the numerator being the total number of hospital encounters that resulted in an ICD-10 code with a mental health diagnosis and the denominator being the population for each ZCTA each month. Because patients are included in inpatient or outpatient based on where they were discharged, inpatient and outpatient data are not duplicative. In other words, patients who were admitted to the emergency room but transferred to a hospital stay would be counted only as inpatient data, not outpatient. Mental health diagnoses include any sort of mental health cases including anxiety, depression, substance use disorder, etc. (full list in the supplemental materials). We create race-specific measures of mental health diagnoses per 1000 by aggregating ZCTA-month mental health incidents by Black, Latine, and White racial subgroups.

Exposures

Our exposure measures of police violence are constructed from the Minneapolis Police Department's Officer Involved Shooting public database. The Department defines officer-involved shootings as any incident where an on-duty police officer discharges a firearm during an encounter. We first aggregate the number of police shootings in each ZCTA-month. We then operationalize exposure to police-involved shootings in two ways: (1) a cumulative counter of police-involved shootings within each ZCTA, summing all shootings from January 2016 up to each month through December 2020, and (2) a one-month lag of whether a shooting occurred within each ZCTA in the prior month.

The cumulative counter is the rolling total of shootings that have occurred within each ZCTA up until a given time, capturing the *cumulative* — or "piling on" — effects of police firearm violence. The prior month measure is a binary variable that captures whether a ZCTA experienced a shooting in the previous month, capturing the impact of *recent* exposures of police firearm violence. The recency exposure's lag structure captures the effect of prior police shootings on mental health diagnosis rate and alleviates simultaneity bias between police shootings and mental health — the potential impact of mental health diagnosis rate on police shootings. These measures allow us to explore both the cumulative and immediate effects of police firearm violence on mental health at the community-level.

Controls

Our panel design and two-way-fixed-effects (TWFE) modeling strategy controls for time-invariant between-space variance (e.g., time stable mental health differences) and space-constant shared time variance across space (e.g., shared seasonality in mental health). Our inferences rely upon the assumption that our exposures of interest (i.e., police shootings) are independent of unobserved within-ZCTA time-varying variance that is not commonly shared across space. We control for time-varying socioeconomic and demographic factors at the ZCTA level to further isolate the effect of the exposures of interest given that they may confound the police shooting exposure-mental health relationship (see covariate

list and data sources in the supplemental materials). We also constructed a concentrated disadvantage index using an established confirmatory factor analysis (CFA) protocol [14, 19]. Concentrated disadvantage is the proportion of households within a census tract with high indexed levels of disadvantage as measured via the following variables: unemployment rate, poverty rate, female head of household rate, and no high school diploma rate (CFA fit statistics: χ^2 (df = 6) = 1728.245, $p < 0.05$, TLI = 1.000, CFI = 1.000, SRMR = 0.000).

Expectations

Based on prior research, we expect both contemporaneous and cumulative exposure to police violence will be associated with the rate of mental health diagnoses. It is unclear whether the cumulative number of police shootings has a linear positive effect on mental health diagnoses or whether communities eventually become desensitized to the effects of police violence.

Analytical Strategy

We construct time-varying choropleth maps of our focal outcome and exposure variables to examine the spatiotemporal variation in each. To identify the effect of exposure to police shootings on mental health diagnosis rate, our panel design relies upon a two-way fixed effects (TWFE) model, which include fixed effects (FE) for both ZCTA and year-month. The ZCTA FE control for time-constant heterogeneity between ZCTAs (i.e., differences in mental health diagnosis rate, healthcare access, etc.) and the year-month FE remove space-constant time heterogeneity (i.e., changes in mental health resources across the city). Our cumulative exposure measure is expressed as a second-degree polynomial, to allow for a potential nonlinear relationship between cumulative police shooting exposure and mental health diagnosis rate. Our specification is as follows:

$$MH_{it} = \alpha + \beta_1 S_{it-1} + \beta_2 \sum_{t=1}^{t} S_{it+} \beta_3 \sum_{t=1}^{t} S_{it}^2 + \boldsymbol{\theta} \mathbf{X_{it}} + \gamma_i + \delta_t + \epsilon_{it}$$

MH_{it} is the mental health diagnosis rate per 1,000 people. S_{it} refers to total cumulative shootings and S_{it-1} is the presence of police shootings in the prior month (0/1). α is the expected mental health diagnosis rate in a ZCTA month with no cumulative and recent shootings and all covariates set to 0. Additional mental health diagnoses based on exposure to a shooting in the month prior are represented by β_1 and cumulative exposure to police shootings are represented by β_2. β_3 is the quadratic term that allows the effect of cumulative exposure to police shootings to be non-linear. ZCTA (γ) and year-month (δ) fixed effects account for spatial and temporal heterogeneity, θ represents time-varying covariates (X_{it}), and ϵ is the error term.

Because we are using population data to assess a rare exposure, our discussion of the estimates emphasizes the magnitude and directionality of our results rather than tests of statistical significance.

We present our TWFE estimates with two-way cluster robust standard errors using marginal effects plots, which depict the expected mean rate of mental health diagnoses per 1000 at varying levels of our exposure variables with all other time-varying covariates held at their means. To calibrate our expected mean estimates to the expected levels (given our TWFE demeaning estimator removes between-ZCTA and between month-variation), the average of the summed TWFE (i.e., each ZCTA and month combination) were added to the effect estimates to recover the average marginal prediction across the panel in Minneapolis.

Results

Descriptive Results

Figure 1 depicts the spatiotemporal variation in our outcome, mental health diagnosis rate per 1000 people, and exposures, cumulative police shootings, and average recent monthly police shootings, in each ZCTA from 2016 to 2020. The mean mental health diagnosis rate is 13.32 mental health diagnoses per 1000 people. Across the ZCTAs, we generally observe on average a slight increase and then decrease in yearly rate of mental health diagnosis and then an eventual decrease.

There were 84 police shootings in Minneapolis between 2016 and 2020. Eight ZCTAs experienced at least one police shooting while 14 ZCTAs had no police shootings from 2016 through 2020. The area represented by ZCTA 55411, in North Minneapolis, had the most cumulative shootings with 11 shootings.

Overall, we observe that areas with the highest rate of mental health diagnosis have a positive but weak correlation to the areas with prior month shooting exposure (r(108) = 0.07, $p = 0.44$, 95% CI [−0.11, 0.26]) and cumulative shootings (r(108) = 0.08, $p = 0.39$, 95% CI [–0.11, 0.27]).

The geographic distribution of areas with at least one prior-month total shootings per year varies over time (Fig. 1). Areas closer to downtown and the northern parts of Minneapolis, which have historically experienced heavier dosages of policing, tend to have at least one prior-month total police shooting. A similar trend is observed for cumulative shootings, with northern Minneapolis (particularly areas extending from downtown) experiencing the highest cumulative exposure to shootings between 2016 through 2020.

Overall Two-Way Fixed Effects Panel Model

We model mental health diagnosis rate per 1000 Minneapolis residents as a function of our focal temporal police shooting exposures, alongside time-varying covariates in a TWFE panel specification (see model estimates in supplemental materials). In the overall population, the expected rate of mental health diagnosis per 1000 with no cumulative exposure of police shootings is 13.07 (95% CI: [5.28, 20.86]).

We observe that cumulative shootings exhibit a non-linear effect: each additional police shooting is associated with a slightly higher level of mental health diagnoses peaking at 5 cumulative shootings and 14.93 (95% CI: [7.13, 22.72]) mental health diagnoses per 1000 people (left panel Fig. 2). This indicates that a ZCTA exposed to 5 cumulative shootings is expected to have about 1.86 more mental health diagnoses per 1000 as compared to a ZCTA with no police shooting exposure. At the mean total population of Minneapolis ZCTA-years across the panel (21,165.02), this implies an additional 39.37 mental health hospitalizations for a Minneapolis ZCTA of average population size. After this peak, the effect begins to reverse as more police shootings accumulate ($\beta_2 = 0.74$, 95% CI [−0.09, 1.57]; $\beta_3 = -0.07$, 95% CI: −0.15, 0.01]). This suggests that initial exposures to police firearm violence garner modestly higher rates of mental health diagnosis but that communities experiencing the highest cumulative load are associated with reduced mental health diagnoses with each subsequent exposure.

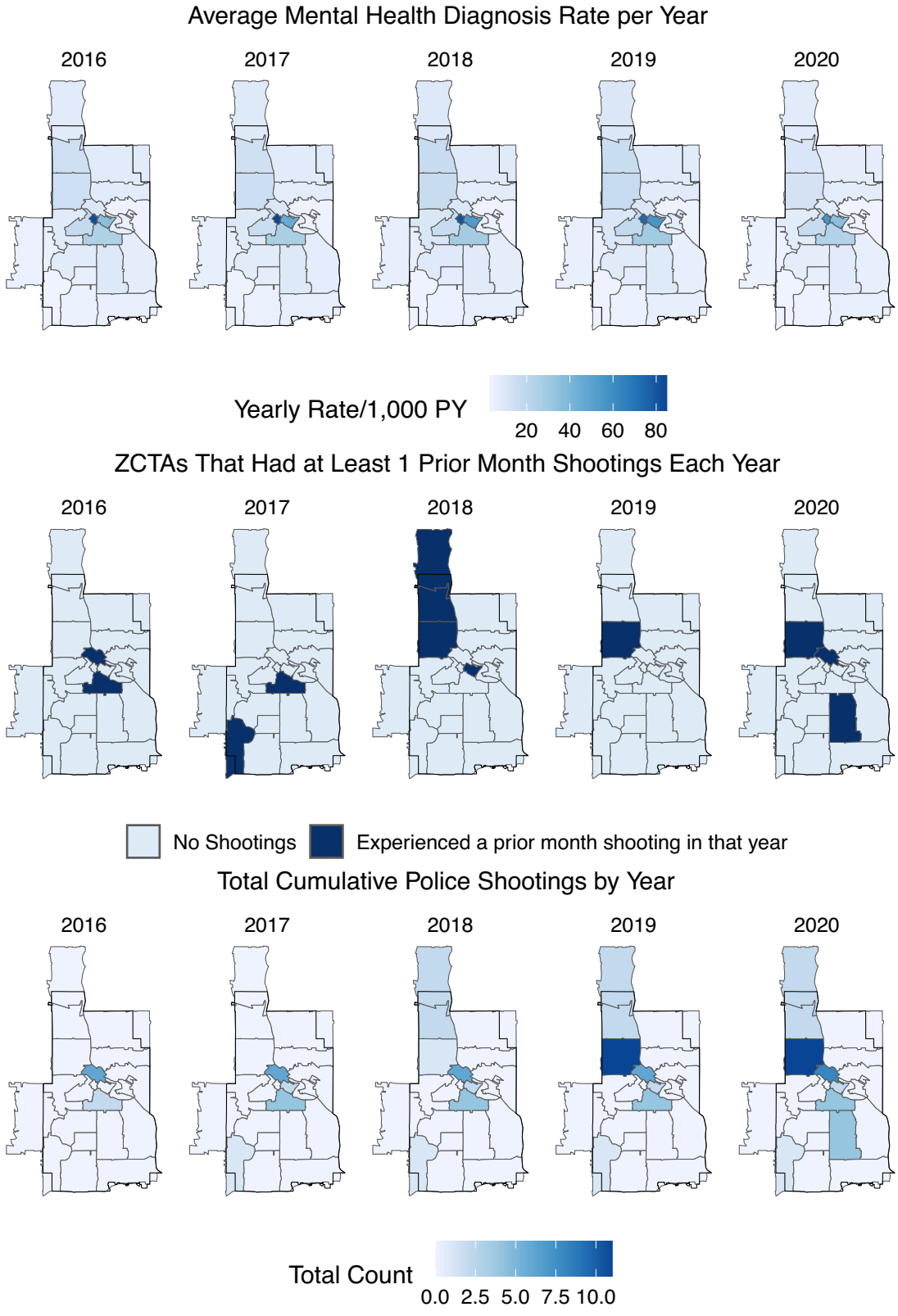
In the right panel of Fig. 2, we depict the marginal effect of at least one shooting in the prior month shooting exposure to explore the role of recent shootings. The expected rate of mental health diagnosis per 1,000 with no exposure to police shootings in the prior month is 14.03 (95% CI: [6.23, 21.84]). In contrast, the expected rate of mental health diagnosis per 1,000 with no exposure to police shootings in the prior month is 15.07 (95% CI: [7.32, 22.81]). Thus, exposure to a shooting in the month prior is associated with 1.03 ($\beta_1 = 1.03$, 95% CI [−0.24, 2.31]) more mental health diagnoses per 1000 as compared to a ZCTA with no prior monthly shootings.

Race-Specific Two-Way Fixed Effects Panel Models

We estimate TWFE specifications for race-specific mental health. The racial subgroup models exhibit similar nonlinear effects of cumulative police shooting exposure on mental health diagnoses per 1000 people.

Black, Latine, and White sub-populations each experienced an initial increase in mean mental health diagnoses, reaching a peak before subsequently declining (left panel Fig. 3). Notably, the mean level of effect and the cumulative number of police shootings associated with these changes varied across populations. At zero cumulative shootings, we observe that each sub-population experienced somewhat similar levels of mental health diagnoses. The Black population had a baseline mean level 5.35 (95% CI: [−1.49, 12.20]) additional mental health diagnoses per 1000 people, followed by the Latine population at 4.16 (95% CI: [−12.35, 20.65]), and then the White population at 3.11 (95% CI: [−2.10, 8.32]). Similar to the overall model, we find that each additional cumulative police shooting is associated with a steady increase in mental health diagnoses for each population, before diminishing in effect and turning negative at high exposure levels. However, the magnitude of each nonlinear effect in the racial subgroup models are different (see estimates in the supplemental materials).

The estimated peak mean level of effect of police shooting exposure was largest in the Latine community, despite Black mental health diagnoses starting at a slightly higher baseline mean level. The Latine community had a peak mean level of 9.95 (95% CI: [−5.23, 25.14]) cases of mental health diagnosis per 1,000 Latine people at 5 accumulated shootings.


Average Mental Health Diagnosis Rate per Year
2016
2017
2018
2019
2020
Yearly Rate/1,000 PY
20 40 60 80
ZCTAs That Had at Least 1 Prior Month Shootings Each Year
2016
2017
2018
2019
2020
No Shootings
Experienced a prior month shooting in that year
Total Cumulative Police Shootings by Year
2016
2017
2018
2019
2020
Total Count
0.0 2.5 5.0 7.5 10.0

◂**Fig. 1** Spatiotemporal variation in mental health diagnosis rate and police shooting exposure, 2016–2020

This exceeds the peak observed in the Black population, 6.31 (95% CI: [−0.55, 13.17]) mental health diagnoses per 1000 people at 3 accumulated shootings, and the White population, 3.99 (95% CI: [−1.22, 9.18]) mental health diagnoses per 1000 people at 6 accumulated shootings. At the average total population size of Minneapolis ZCTA-years across the panel for each sub-population (Latine: 1993; Black: 3872; White: 13,724), these findings imply an additional 19.83, 24.43, and 54.76 mental health diagnoses, respectively, for the Latine, Black, and White populations.

Observing the coefficients, the Black model indicates that each additional cumulative police shooting exposure resulted in increased mental health diagnoses ($\beta_2 = 0.59$, 95% CI: [−0.18, 1.37]), with a diminishing effect ($\beta_3 = -0.09$, 95% CI: [−0.16, 0.02]), which are lower in magnitude as compared to the Latine model. The White model also indicates that each additional cumulative police shooting exposure resulted in increased mental health diagnoses with a diminishing effect; however, the magnitude of these are much lower than the Black and Latine populations ($\beta_2 = 0.30$, 95% CI: [−0.15, 0.75]; $\beta_3 = -0.03$, 95% CI: [−0.07, 0.02]). The Latine model, however, has a wider confidence interval for the cumulative exposure effect, indicating considerable variation within this population likely due to small population sizes. We note that this peak occurs earlier for Black populations compared to the Latine and White populations.

The right panel of Fig. 3 visualizes the effect of at least one shooting in the prior month, recent shootings, on the rate of mental health diagnoses for each sub-population. The effect of recent shootings is generally stable for Black, Latine, and White populations. This contrasts with what we observed in the

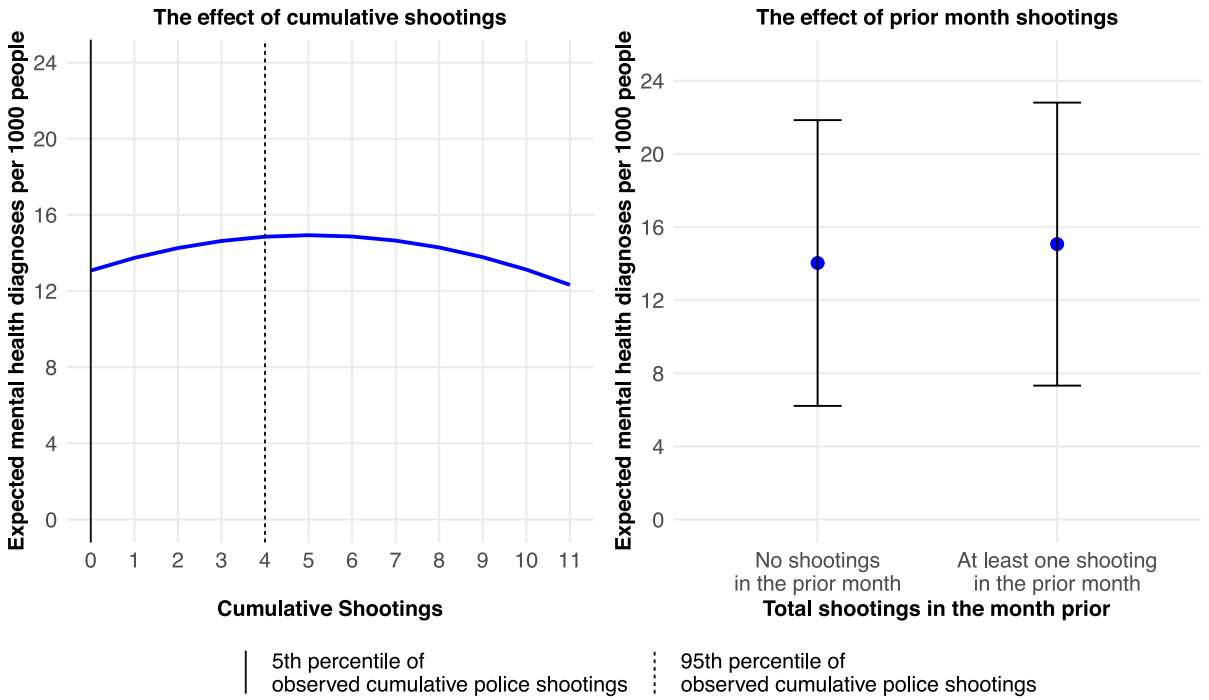


Fig. 2 Marginal effects graphs depicting the average additional mental health cases associated with each additional cumulative shooting (left) and prior month total shooting (right)

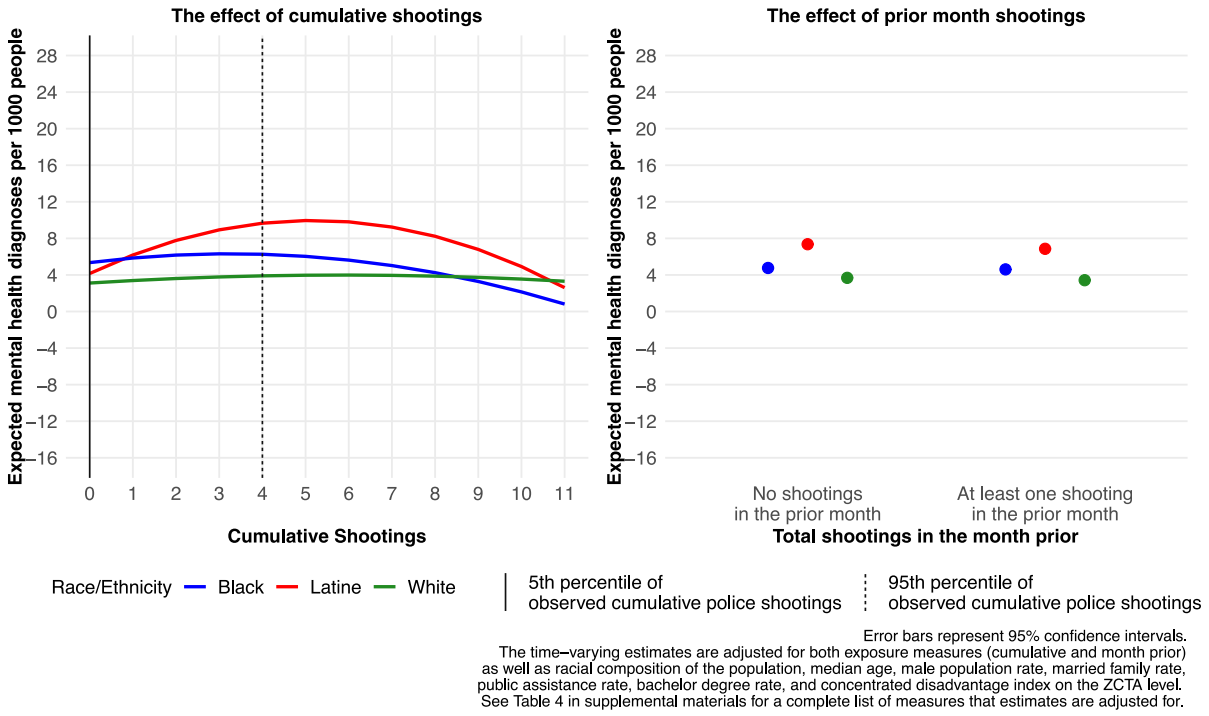


Fig. 3 Marginal effects graphs depicting the average additional mental health cases associated with each additional cumulative shooting within Black, Latine, and White populations (left) and prior month total shooting (right)

overall population where additional total prior month shootings resulted in slight increases to mental health diagnoses.

Discussion

Our study examined the cumulative and recent impact of vicarious exposure to police shootings on community-level mental health. Our design improves on previous work by estimating the longitudinal nature of vicarious police shooting exposure, using electronic medical records from hospitals, which provide objective, time-accurate data [20]. We observed that, between January 2016 and December 2020, the effect of each additional cumulative exposure to police shootings in Minneapolis, Minnesota resulted in initial increases in the level of mental health diagnosis, followed by a maximum and then a decline in effect — a non-linear, parabolic pattern. We observed a small increase in effect on mental health diagnosis incidents among those exposed to at least one recent shooting in the overall population.

The non-linear, parabolic pattern in the effect of each additional cumulative shooting on mental health diagnoses may be explained by sensitization, desensitization, and system avoidance. Sensitization occurs when repeated exposure to a stimulus results in the gradual amplification of a response [21]. Communities may remain sensitive to police shooting events and have stress that intensified as shootings accumulate and results in increasing levels of mental health diagnoses, which has also been observed in previous studies [15, 16]. However, we observed that this trend does not continue indefinitely. Following the initial incremental increase in effect of each additional cumulative shootings on mental health diagnosis, we observe a peak and then an incremental decline in effect. This curvilinear pattern is consistent with studies that have linked reduced mental health or emotional distress to the accumulation of direct or indirect community violence exposure [22–24]. As hypothesized in prior studies, repeated exposure to community violence may lead to desensitization and normalization in highly exposed communities, resulting in declining marginal effects on mental health

diagnoses as cumulative exposure increases beyond a certain threshold [22–24]. Our findings suggest that additional indirect exposure to police shootings may function similarly as community violence on local mental health [22–24]. The eventual decline in effect of additional shootings on mental health condition diagnosis could also reflect system avoidance — wherein exposed residents become more likely to avoid recordkeeping institutions such as hospitals [25, 26]. Exposure to police violence has been associated with increased hypervigilance, which in turn contributes to system avoidance [11]. Thus, system avoidance may play a role in our case given that exposure to police violence and policing is associated with unmet medical needs [27], greater reports of poorer health, and substantially decreased emergency department visits [28]. Exposure to a greater number of police shootings in an area may increase hypervigilance and reduce the likelihood that residents seek medical treatment in hospitals, resulting in fewer detected mental health diagnoses in hospital contexts even if mental health remains stable or even increases.

Findings also highlight how the cumulative effects of police shootings are racialized. Though each population experiences a similar non-linear, parabolic effect, compared to White populations, Latine and Black populations experience a greater peak and earlier decline in effect of cumulative shootings on mental health diagnosis. The greater maximum effect observed among Latine and Black populations may be due to their higher exposure to police violence, which has been found to have a more severe impact on their mental health compared to White populations [4, 5, 8, 16, 29, 30]. The impact of police shooting exposure may be muted for Black and Latine populations compared to White populations due to desensitization, system avoidance, and stigma around mental health care leading to fewer detected diagnoses despite elevated psychological distress, similar to the Black-White mental health paradox [31]. Interventions could aim to address barriers for Black and Latine communities by reducing stigma around mental health care, improving service access, and intervening early in areas following incidents of police shootings.

This study has several limitations. First, we only observe data from a single jurisdiction, Minneapolis, Minnesota, and thus, these data may not be generalizable. Regardless, Minneapolis serves as an important case study given its national significance in conversations around policing and racial justice [32] and enables analysis at the ZCTA level, allowing for a granular analysis of the spatial effects of police shootings. Second, this study did not include non-shooting injuries or fatalities by police, such as the 2020 murder of Mr. George Floyd who was strangled to death by a police officer in Minneapolis. Third, this study only captures police shootings between 2016 through 2020 due to data limitations. Our effects do not reflect the associated trauma from those earlier incidents beyond any potential conditioning of our observed effects from unobserved previous ones. Moreover, we caution that exposure to a high number of police shootings is relatively rare in our data, with only 5% of the ZCTAs being exposed to 4 cumulative shootings or more, therefore our inferences in this range are based upon a limited number of observations. The final study year, 2020, included COVID-19 and George Floyd's murder, events that likely affected Minneapolis residents' mental health and may confound observed associations. We address this limitation by using four years of police shooting and mental health diagnosis data to capture a longer period of cumulative exposure. Additionally, if unmeasured time-varying changes in residential mobility are driven by police shooting exposure and impacted residents move elsewhere, this could (a) stunt the accumulation of collective memory regarding racialized police violence [33], or (b) structurally reduce observed hospitalizations within Minneapolis. Our final limitation is that outcome data reflected only those who accessed healthcare. Individuals may not seek mental healthcare after police shooting exposure due to limited access, stigma, or resolution of acute symptoms.

This study adds to the growing literature that identifies mental health illness as an integral consequence of the "slow violence" of American policing [34]. While violence has long been "attritional, dispersed, and hidden" [35], we find that it propagates to impact entire communities. Our findings suggest that community mental health diagnosis rate is more sensitive to the cumulative number of police shootings over time than exposure to police shootings in the month prior, consistent with the "slow violence" account of policing. This study contributes to the existing literature that police violence exposure, even vicarious

exposure, has negative impacts on mental health diagnosis rate and can be considered a social determinant of health [36]. These findings can inform advocacy for the reduction and elimination of police violence, including alternatives to policing like behavioral crisis response teams. Policymakers should consider strategies to address acute and serious mental health cases following police shootings, especially within ZCTAs with prior police shootings.

Police shootings are harmful and traumatic and may differentially influence mental health given differing community burdens of exposure and racialized marginalization. Police violence may engender contexts in which individuals either do not get the medical care they need, or become desensitized to extreme state violence that could, in turn, result in further exposure. Our findings suggest a need for early intervention to minimize the harms of police shootings on community mental health if and when they occur.

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