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Supplementary appendix

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Supplemental Appendix

**Police Killings and Their Spillover Effects on the Mental Health of Black Americans:
A Population-Based, Quasi-Experimental Study**

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A. Statistical Methods

To estimate the causal effect of police killings of unarmed black Americans on self-reported mental health in the general population of black American adults in the United States, we fit least squares multivariable regression models of the following form:

$$Y_{i,j,t} = \alpha \times PoliceKillings_{j,t} + \boldsymbol{\beta} \times \boldsymbol{X}_{i,j,t} + \sum_k \gamma_k \times 1[YearMonth_t = k] + \sum_l \delta_l \times 1[StateMonth_{jt} = l] + \varepsilon_{i,j,t}$$

where i indexes the individual respondent, j the state of residence, and t is the exact date of the BRFSS interview. $Y_{i,j,t}$ denotes the primary outcome of interest, i.e. the number of days with poor mental health in the past month reported by individual i in state j on date t. $PoliceKillings_{j,t}$ represents the total number of police killings of unarmed black Americans in the respondent's state of residence during the three-months prior to the exact date of the BRFSS interview. The term $\boldsymbol{X}_{i,j,t}$ is a vector of individual-level covariates: day-of-week fixed effects, age (flexibly specified in 5-year age categories), sex, and educational attainment (less than high school, high school, some college, and college). $\boldsymbol{\beta}$ is a vector of coefficients on those covariates. The variable $YearMonth_t$ is the calendar month and year of the BRFSS interview and takes the values (k = January 2013, February 2013, ..., December 2015). The term $\sum_k \gamma_k \times 1[YearMonth_t = k]$ denotes a series of year-month fixed effects, which adjust flexibly for national secular trends that could confound the association between our exposure and outcome. The variable $StateMonth_{jt}$ refers to the state and month of the BRFSS interview and takes the values (l = Alabama-Jan, Alabama-Feb, ..., Wyoming-Dec). The term $\sum_l \delta_l \times 1[StateMonth_{jt} = l]$ denotes a series of state-month fixed effects, which adjust for any state-specific time-invariant characteristics as well as state-specific seasonal fluctuations (e.g. due to weather) that may be jointly correlated with the exposure and the outcome. We also estimated a version of this model replacing $PoliceKillings_{j,t}$ with a binary indicator for any police killing of an unarmed black American in the same state of residence within the three months prior to interview (vs none).

Our estimator for the effect of interest is α, which is the change in the number of poor mental health days associated with each additional police killing of a black American in the same state in the prior three months. Estimates of α compare the mental health of individuals residing in the same state but who were surveyed on different dates and therefore had different exposures.

The key causal identifying assumptions in our strategy are (1) no endogenous selection into the sample—ie, the timing of the BRFSS interview and participation in the interview were random relative to the timing of police killings, an assumption supported by the random-digit-dial approach to sampling and by our investigation of differential participation following police killings; and (2) unconfoundedness—ie, police killings did not coincide with other factors that could influence mental health. After including state-month and year-month fixed effects, the only unobserved confounders that could remain would be factors that varied at the state-year-month level and whose timing was correlated with police killings and mental health in ways that deviated from normal state-specific seasonal patterns. The unconfoundedness assumption is supported by the quasi-random timing of specific police killings. To the extent that these assumptions are satisfied, our estimates can be interpreted as causal effects. We test violations to each of these assumptions in a number of specification checks.

One such check was estimating an "event study" model. In this model, we replaced the number of police killings in the last three months ($PoliceKillings_{j,t}$) with a series of count variables representing the number of police killings of unarmed black Americans in each of the six months preceding and after the BRFSS interview. The estimated regression coefficients on the six monthly variables prior to interview permitted us to examine the month-by-month trajectory of mental health impacts. Due to the wording of the poor mental health days survey question, the event study estimates should be interpreted with the 30-day lag in mind: individuals interviewed within one month after a shooting had a recall period in which, on average, only 50% of the days were exposed.

The event count model also provides a useful test for the presence of unobserved confounding by state-specific, time-varying factors, because it also estimates the causal spillover effect on mental health of police killings occurring in the months *after* the interview. Logically, these exposures could have no impact on prior assessments of mental health. Therefore, we expected that the estimated regression coefficients for police killings occurring in the

months after interview would be statistically indistinguishable from zero. If not, this would suggest the importance of unmeasured confounders in driving our main findings.

We estimated a number of additional checks:

(A) Robustness of the main findings to inclusion of additional covariates – We examined robustness to adjusting for
   o Income
   o State-year fixed effects (Alabama 2013, Alabama 2014, …, Wyoming 2015) to capture state specific trends that may be jointly correlated with trends in mental health and police killings
   o Census division-year-month fixed effects (New England Jan 2013, New England Feb 2013, …, Pacific Dec 2015) to adjust to region-specific secular trends in the outcome (eg, economic or weather shocks)

(B) Assessment of selection into the sample – We assessed whether police killing events changed the type of person who was more likely to enter the BRFSS sample (age, gender, education level).

(C) Specificity of findings – We assessed effects of police killings of unarmed black Americans on mental health outcomes for Whites; effects of police killings of armed black Americans on both black American and White mental health; and effects of police killings of unarmed Whites on black American and White mental health. The main motivation of this analysis is to investigate our causal mechanism. If the mental health consequences of police killings manifest through changing perceptions around structural racism, we would not expect to find any substantive impacts in each of these additional analyses. We did not ex ante specify models examining the consequences of police killings of armed white Americans because our intent was to assess the sensitivity of our findings to changes in the race or armed status of the victim, holding fixed at least one of these attributes. These specifications provide the sharpest, most stringent test of whether killings of black, unarmed victims have specific salience to health outcomes.

As noted in the discussion, our empirical strategy likely underestimates the true impacts of police killings for several reasons. First, it assumes that the relevant exposure is entirely contained within the state of residence, i.e., police killings only affect the mental health of respondents in the same state. However, we acknowledge that many police killings of unarmed black Americans have received broad, even nationwide coverage in the media, even if interest is highest within the state of occurrence (eFigure 1). National spillovers are not captured in our estimates. Second, to the extent that the consequences of police killings of unarmed black Americans reverberate across state boundaries, our regression models would yield *underestimates* of the state-level mental health impacts because the control states would be partially exposed. Third, if the relevant exposure occurs at a more local level – such as at the level of neighborhoods or of the county – then our aggregate population-level effect would be an underestimate of the effect experienced by groups most directly exposed. Fourth, police killings are systematically under-reported in official sources, and it is possible that some killings that were not well publicised were missed even in the MPV database. In our sample, race or ethnicity was unknown for 7.3% of killings of unarmed victims and these were excluded. To the extent that these missing events have mental health consequences of their own, omitting them would bias downwards our estimates of the population mental health impact of police killings. Misattribution of the armed status of a victim, if random, could also bias our estimates toward the null. For all these reasons, our estimates should be regarded as conservative.
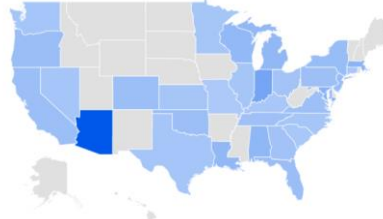
B. Supplementary Figures

eFigure 1 - Geographic distribution of internet searches for names of selected unarmed black Americans killed by police in Google Trends, 2013-2016
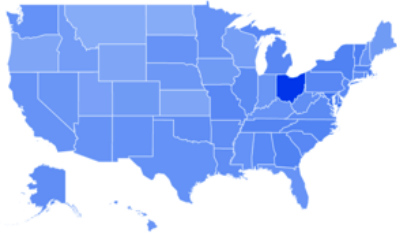
Dontre Hamilton, April 30, 2014
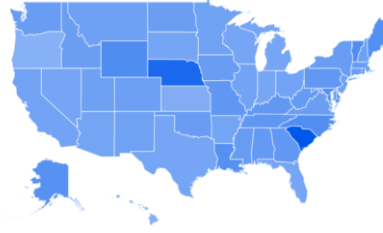Milwaukee, Wisconsin
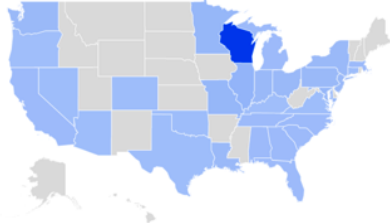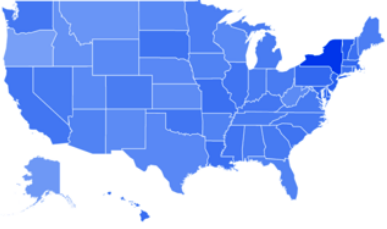
Rumain Brisbon, December 2, 2014
Phoenix, Arizona

Tamir Rice, November 22, 2014
Cleveland, Ohio

Walter Scott, April 4, 2015
North Charleston, South Carolina

Eric Garner, July 17, 2014
Staten Island, New York

Freddie Gray, April 19, 2015
Baltimore, Maryland
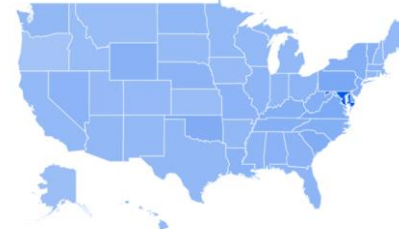
Michael Brown, August 9, 2014
Ferguson, Missouri
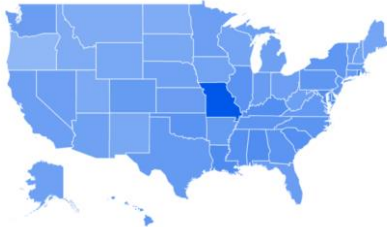
Keith Lamont Scott, September 20, 2016
Charlotte, North Carolina
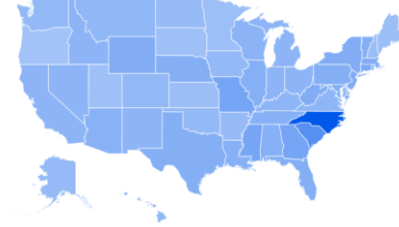
Notes: Figure plots Google search volume by state for selected, nationally reported police killings of unarmed black Americans. These data were obtained using Google trends (https://trends.google.com/trends/?geo=US) for the period January 2013 to December 2016, with searches conducted using the name of the deceased. For each search, the darkest blue shaded state represents area with the highest volume of searches (normalized to a value of 100).

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eFigure 2 - Police killings of unarmed black Americans, by state

Legend:
- 10 – 30
- 6 – 10
- 3 – 6
- 2 – 3
- 1 – 2
- No data
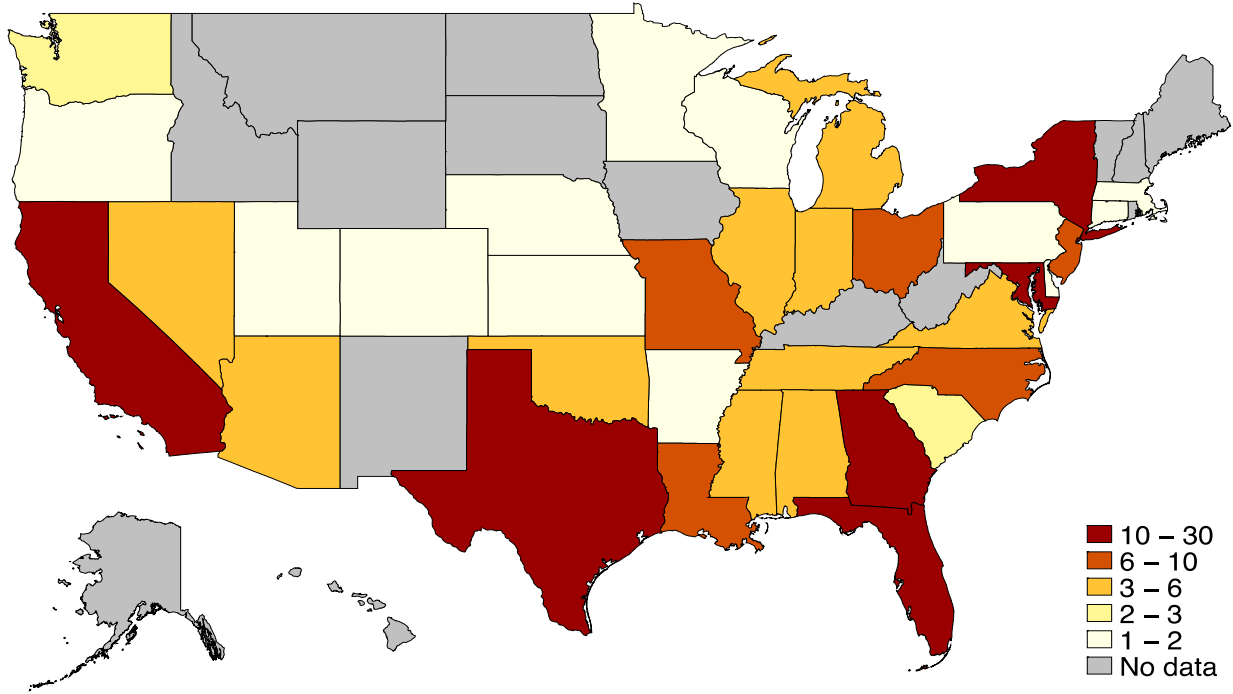
Notes: Figure plots the total number of police killings of unarmed black American individuals between 2013-2016 in Mapping Police Violence project database.

C. Supplementary Tables

eTable 1 – Sensitivity of Main Findings to Inclusion of Additional Covariates

	Add Income		Add State-Year FE		Add Census Division-Month-Year FE	
	(1)	(2)	(3)	(4)	(5)	(6)
# of Police Killings of Unarmed Black Americans, 3 Months Prior	0·15 (0·059, 0·23) p=0·002		0·21 [0·07, 0·34] p=0·004		0·15 [0·053, 0·25] p=0·003	
Any Police Killings of Unarmed Black Americans, 3 Months Prior (=1)		0·27 [-0·037, 0·58] p=0·082		0·39 [0·07, 0·72] p=0·020		0·31 [-0·03, 0·65] p=0·076
N	87,783	87,783	103,710	103,710	103,710	103,710

Notes: Models are identical to those presented in Table 3 except here we additionally added (1) categories of income as an independent variable (household income <$10,000/year, $10-$15,000, $15-20,000, $20-$25,000, $25-$35,000, $35-$50,000, and above $50,000 - the sample size is smaller than in Table 2 because some individuals responded that they were unsure or did not know their household income), (2) state-year fixed effects, and (3) census division-month-year fixed effects. Census divisions represent 9 groupings of U.S. states by geography: https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf. (See Table 3 notes for additional details.

eTable 2 - Testing for Selection into BRFSS Sample on Observable Characteristics

	Age (Years)		Female Gender (=1)		College Education (=1)	
	(1)	(2)	(3)	(4)	(5)	(6)
# Police Killings of Unarmed Black American Individuals in Preceding 3 Mo.	-0·033		-0·0004		-0·001	
	[-0·31, 0·24]		[-0·007, 0·007]		[-0·006, 0·003]	
	p=0·81		p=0·90		p=0·64	
Any Police Killing of Unarmed Black American Individuals in Preceding 3 Mo.		-0·012		-0·002		-0·002
		[-0·72, 0·70]		[-0·013, 0·009]		[-0·017, 0·014]
		p=0·97		p=0·71		p=0·82
N	105,322	105,322	106,722	106,722	106,722	106,722

Notes: Multivariable regression estimates (ordinary least squares). Models are identical in structure to those in Table 3 of the main text, except here the dependent variables are individual respondent demographic and SES characteristics (provided in column header) and the models adjust for same covariates as those in Table 2 except the variables named in the column headers. The intuition is to assess whether exposure to an unarmed killing in the same state in the three months prior to interview changed the distribution of respondents. 95% CI, corrected for clustering at the state level, are provided in the square brackets, with p-values below.

eTable 3 – **Mental Health Consequences by Exposure to One versus Two or More Police Killings**

	Poor Mental Health Days
	Least Squares, b
1 Police Killing of Unarmed Black Americans in the 3 months Prior to Interview	0·38
	[0·056, 0·71]
	p=0·023
2 or More Police Killings of Unarmed Black Americans in 3 Months Prior to Interview	0·30
	[-0·059, 0·66]
	p=0·099
N	103,710

Notes: Model is identical to those presented in Table 3, except here we estimate a "dose response" relationship. Specifically, we distinguish to being exposed to a single police killing of an unarmed black victim in the three months prior to interview (n=21,129, 22% of the weighted sample) and being exposed to 2 or more such killings (n=16,729, 27% of the weighted sample). The reference group is no police killing of an unarmed black victim in the three months prior to interview.

eTable 4 - Results by Age, Gender, Education, and Income Sub-Groups

	Men	Women	Age 18-34	Age 35-49	Age 50-64	Age 65+	< High School	High School	Some College+	Income <35K	Income 35K+
# of Police Killings of Unarmed Black Americans, 3 Months Prior	0.14 [-0.007,0.28] p=0.062	0.17 [0.058,0.29] p=0.004	0.007 [-0.18, 0.19] p=0.94	0.13 [-0.11, 0.37] p=0.285	0.27 [0.057, 0.48] p=0.014	0.18 [-0.058, 0.41] p=0.14	0.27 [-0.07, 0.60] p=0.117	0.045 [-0.095, 0.19] p=0.519	0.18 [0.07, 0.28] p=0.002	0.11 [-0.07, 0.30] p=0.223	0.143 [0.004, 0.28] p=0.045
Any Police Killings of Unarmed Black Americans, 3 Months Prior (=1)	0.38 [-0.16, 0.92] p=0.17	0.37 [0.018, 0.72] p=0.04	0.24 [-0.15, 0.64] p=0.22	0.15 [-0.42, 0.72] p=0.60	0.54 [-0.01, 1.01] p=0.054	0.17 [-0.44, 0.79] p=0.566	0.92 [-0.12, 1.95] p=0.081	0.30 [-0.08, 0.69] p=0.118	0.29 [-0.13, 0.68] p=0.172	0.068 [-0.59, 0.73] p=0.83	0.20 [-0.10, 0.50] p=0.19
N	36,026	67,681	18,088	21,015	34,612	28,973	13,319	34,032	56,341	40,404	47,464

Notes: Model is identical to those presented in Table 3, except here we estimate models for different subgroups based on gender, age, education, and income. Differences in point estimates across each set of subgroups were not statistically significant (not shown here to reduce clutter).

eTable 5 - Results by Race of Respondent, Race of Victim, and Whether the Victim was Armed

	(1)	(2)
Panel A - Impact of Police Killings of Unarmed Black Americans on White American Outcomes		
# Police Killings of Unarmed Black American Individuals in Preceding 3 Mo·	-0·0098	
95% CI	[-0·045, 0·026]	
P-value	0·58	
Wild cluster bootstrap-t p-value		
Any Police Killings of Unarmed Black American Individuals in Preceding 3 Mo		0·024
95% CI		[-0·066, 0·11]
P-value		0·59
Wild cluster bootstrap-t p-value		
N	837,124	837,124
Panel B - Impact of Police Killings of Armed Black Americans on Black American Outcomes		
# Police Killings of Armed Black American Individuals in Preceding 3 Mo·	-0·014	
95% CI	[-0·12, 0·096]	
P-value	0·80	
Wild cluster bootstrap-t p-value		
Any Police Killings of Armed Black American Individuals in Preceding 3 Mo·		-0·078
95% CI		[-0·35, 0·20]
P-value		0·57
Wild cluster bootstrap-t p-value		
N	105,084	105,084
Panel C - Impact of Police Killings of Armed Black Americans on White American Outcomes		
# Police Killings of Armed Black American Individuals in Preceding 3 Mo·	0·021	
95% CI	[-0·003, 0·046]	
P-value	0·079	
Wild cluster bootstrap-t p-value		
Any Police Killings of Armed Black American Individuals in Preceding 3 Mo·		-0·048
95% CI		[-0·13, 0·035]
P-value		0·25
Wild cluster bootstrap-t p-value		
N	903,027	903,027
Panel D - Impact of Police Killings of Unarmed Whites on Black American Outcomes		
# Police Killings of Unarmed White Individuals in Preceding 3 Mo·	0·103	
95% CI	[0·004, 0·20]	
P-value	0·043	
Wild cluster bootstrap-t p-value	0·16	
Any Police Killings of Unarmed White Individuals in Preceding 3 Mo·		0·17
95% CI		[-0·15, 0·49]
P-value		0·29
Wild cluster bootstrap-t p-value		0·32
N	99,609	99,609
Panel E - Impact of Police Killings of Unarmed Whites on White American Outcomes		
# Police Killings of Unarmed White Individuals in Preceding 3 Mo·	0·0013	
95% CI	[-0·048, 0·051]	
P-value	0·96	
Wild cluster bootstrap-t p-value		
Any Police Killings of Unarmed White Individuals in Preceding 3 Mo·		-0·0027
95% CI		[-0·095, 0·090]
P-value		0·95
Wild cluster bootstrap-t p-value		
N	978,915	978,915

Notes: Regression estimates from multivariable ordinary least squares models. Each panel-column represents a separate regression. The dependent variable is the number of days of poor mental health. Models are identical to those presented in Table 3, except here we examine either different populations (white American respondents), different exposures (police killings of unarmed African Americans, police killings of armed black Americans, or police killings of unarmed white Americans), or both. The specific analysis group and exposure is noted in the column header. 95% CI, corrected for clustering at the state level, are provided in the square brackets, with p-values and Wild cluster bootstrap p-values below.