DEPARTMENT of



BIOSTATISTICS EPIDEM LOGY & **INFORMATICS**

Introduction

The COVID-19 pandemic has disproportionately impacted racial/ethnic minority and socioeconomically disadvantaged groups in the United States¹, including at-risk populations within Southeastern Pennsylvania. We sought to determine whether neighborhood-level health, demographic, and socioeconomic characteristics in Southeastern Pennsylvania were associated with COVID-19 incidence and mortality at the zip code and municipality level, thereby establishing whether neighborhood-level disparities mirror individual-level ones.

Methods

Data sources Data collected was aggregated by county subdivision geographical units: zip codes in Philadelphia and municipalities in Bucks, Chester, Delaware, and Montgomery Counties. Cumulative zip code- and municipality-level data on COVID-19 cases and deaths were obtained from the public health departments of 5 counties in Southeast Pennsylvania, and those of individual long-term care facilities (LTCFs) were obtained from the Pennsylvania Department of Health. For corresponding geographic areas, demographic and socioeconomic status variables were obtained from the 2015-2019 American Community Survey (ACS) 5-year estimates, and data on the health status and behaviors of local residents were obtained from the Southeast Pennsylvania Household Health Survey, conducted in 2012, 2015, and 2018 by the Public Health Management Corporation. Derived from the ACS 5-year estimates were income disparity, defined as the log of 100 times the ratio of the number of households making less than \$10,000 to the number of households making greater than \$50,000, and Area Deprivation Index (ADI), a validated score of socioeconomic deprivation derived from 17 factors related to education, employment, income, and housing quality.

Feature selection We created univariable quasi-Poisson models with LTCF-excluded COVID-19 case and death counts with offsets for population counts to identify individual factors that were significantly associated (p < 0.01), then selected single variables among those with highly collinear terms in each model, with collinearity established based on having variance inflation factors greater than 3.

Statistical analysis Including only the individual predictors that passed feature selection, we created multivariable quasi-Poisson regression models with offsets for population counts to determine whether neighborhood-level variables were associated with LTCF-excluded COVID-19 incidence and mortality.

Results

Among 276 zip codes and municipalities with complete data, the COVID-19 cumulative incidence through March 12, 2021 ranged from 112.7 to 1206.4 per 10,000 residents, and the COVID-19 mortality rate ranged from 0 to 7.6 per 10,000 residents (Figure 1). Aggregated by county, cumulative incidence ranged from 5.25% (Bucks) to 7.59% (Philadelphia), and cumulative mortality ranged from 0.14% (Chester) to 0.23% (Delaware), including cases and deaths from LTCFs (Table 1). Prevalence estimates of household health characteristics (Table 2) and those of demographic and socioeconomic characteristics for the entire Southeastern Pennsylvania population are shown in **Table 3**.

Factors associated with COVID-19 incidence Three of 23 neighborhood-level variables included in the final model were independently associated with COVID-19 incidence: the proportion of those aged 65 or older increased risk, while median gross rent and the proportion of individuals eating 3 or more servings of fruits/vegetables daily decreased risk (**Table 4**).

Factors associated with COVID-19 mortality One of 16 neighborhood-level variables included in the final model with COVID-19 mortality was independently associated with increased risk: the proportion of individuals aged 65 years or older (**Table 4**).

Figure 1. COVID-19 incidence (A) and COVID-19 mortality (B) by zip code (Philadelphia) and by municipality (Bucks, Chester, Delaware, Montgomery), with long-term care facility data excluded. Prevalence is reported as cases (incidence) or deaths (mortality) per 10,000 residents. County boundaries are indicated in black.



Associations Between Neighborhood-Level Characteristics and COVID-19 Incidence and Mortality in Southeastern Pennsylvania

Alexandra Rizaldi, Sherrie Xie, Rebecca A. Hubbard, and Blanca E. Himes

Department of Biostatistics, Epidemiology and Informatics, University of Pennsylvania, Philadelphia, PA

Mortality 10.0 7.5 5.0 2.5 0.0

Table 1. Cumulative COVID-19 characteristics of individual counties and the Southeast Pennsylvania region as of March 12, 2021. Shown are counts (%) for Cases and Deaths.

	Population	Cases	Deaths	
Bucks County	626806	34479 (5.25)	1285 (0.21)	
Chester County	524590	28391 (5.28)	731 (0.14)	
Delaware County	566514	38534 (6.54)	1287 (0.23)	
Montgomery County	823823	48055 (5.59)	1240 (0.15)	
Philadelphia County	1579305	121844 (7.59)	3178 (0.20)	
SEPA	4121038	271303 (6.40)	7721 (0.19)	

Table 2. Household health characteristics of Southeast Pennsylvania residents derived from Household Health Surveys. Shown are prevalence estimates in percentages for variables among all respondents.

	Estimates
lealth	
Good Health	82.4
Diabetes	12.8
Asthma	17
Hypertension	32.8
Obesity	29.4
3+ of above conditions	10.8
Mental health condition	18.8
ifestyle	
Ever smoked	43.1
Now smoking	17.4
Tobacco use	4.8
Exposed to smoke at home	12.3
3+ fruits/vegetable per day	45.5
Exercise (30 min, 3+ days/week)	54.2
Socioeconomic Status	
Foregone medical care due to cost	91.9
Forgone medication due to cost	56.4
Forgone food due to cost	35.2
Have health insurance	28.6
nsurance Billing Class	
Employer-sponsored	12.1
Private/Personal	2.0
Medicare	10.6
Medicaid	13.8
Military	11.6
Social Capital	
Low	29.5
Medium	52.5
High	23.2

Area-level age was associated with increased risk of COVID-19 incidence, while socioeconomic status and diet were associated with decreased risk of COVID-19 incidence in population-level analysis. Area-level age was also associated with increased risk of COVID-19 mortality. Neighborhood-level data can complement individual-level data, which may not be readily available, to help identify specific needs of vulnerable populations and inform policies to address health disparities related to COVID-19.

Bibliography 1. Abedi, V. et al. (2020). Racial, Economic, and Health Inequality and COVID-19 Infection in the United States. J Racial Ethn Health Disparities, 1–11. 2. Singh G. K. (2003). Area deprivation and widening inequalities in US mortality, 1969-1998. Am J Public Health, 93(7), 1137–1143.

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Table Demographic 3. and socioeconomic characteristics Pennsylvania Southeast residents ACS 2015-2019 5-year derived from Shown estimates. are prevalence estimates in percentages for all variables population density, median median home value, median median monthly mortgage

income disparity, and ADI scor	е.		IRRs for COVID-19 Incidence	IRRs for COVID-19 Mortality
	Estimates	Population		
Deventetien		Population density (people/km ²)	1.00 (1.00, 1.00)	
	000	Sex		
Population density (people/km ²)	886	Male		0.94 (0.54, 1.59)
Sex		Race		
Male	48.2	Latino	1.01 (0.98, 1.05)	
Race		Age		
White	64.9	35-49		0.96 (0.60, 1.52)
Black	22.3	50-64	0.94 (0.84, 1.06)	
Asian	6.5	65+	1.11 (1.02, 1.21)**	2.04 (1.61, 2.58)**
Latino	8.9	Household Size		
Age		2	0.93 (0.86, 1.02)	
18-34	23.9	2_/	0.33 (0.80, 1.02)	0 01 (0 75 1 12)
35-49	18.6	5-4		0.91 (0.75, 1.12)
50-64	20.1	5+ Socioconomio Statuc	0.99 (0.00, 1.12)	
65+	15.6	Modion groop rent (UCD)	0.07 (0.00.0.00)**	0.00 (0.04, 4.00)
Household Size		Median gross rent (USD)	0.97 (0.96, 0.99)**	0.98 (0.94, 1.03)
1	30.2	Housing (% of all nousenoids)		
2	32.1		0.76 (0.55, 1.06)	
3-4	29.1	Crowded	1.19 (0.92, 1.52)	
5+	8.6	Health		
Education Level	010	Diabetes	0.99 (0.88, 1.10)	1.34 (0.90, 1.97)
Less than 9 th grade	3.4	Asthma	0.95 (0.87, 1.04)	1.12 (0.85, 1.48)
High school diploma	90.4	Hypertension		0.97 (0.78, 1.21)
Bachelor's degree	39.7	Obesity	1.00 (0.94, 1.06)	1.12 (0.93, 1.36)
Graduate degree	16.6	Mental health condition	1.00 (0.94, 1.08)	
Socioeconomic Status	10.0	Lifestyle		
Median household income (USD)	70420	Ever smoked	1.01 (0.95, 1.07)	1.02 (0.83, 1.25)
Median home value (USD)	266774	Tobacco use	1.10 (0.97, 1.25)	1.32 (0.87, 1.99)
Median gross rent (USD)	200774	3+ fruits/vegetable per day	0.92 (0.88, 0.97)**	0.91 (0.78, 1.06)
Median monthly mortgage (USD)	1104	Exercise (30 min, 3+ days/week)	0.97 (0.91, 1.03)	
Below 100% poverty level	1886	Socioeconomic Status		
Below 150% poverty level	9.4	Forgone medical care due to cost	0.98 (0.88, 1.10)	0.98 (0.68, 1.40)
Leomo disparity	20.4	Forgone medication due to cost	1.08 (0.97, 1.19)	1.13 (0.80, 1.60)
	2.4	Insurance Billing Class		
	66.0	Private/Personal	1.03 (0.95, 1.11)	
ADISCUIE	74.7	Medicare	1.00 (0.93, 1.08)	0.94 (0.74, 1.18)
		Military	1.36 (0.98, 1.89)	
Owner-occupied	65.3	Social Capital		
Single-parent	14.3	Low	1.03 (0.99, 1.06)	
Without vehicle	15.5	High		0.94 (0.78, 1.11)
Without telephone	1.6			
Without plumbing	2.2			
Crowded	1.9			

Conclusion



Table 4. Incidence rate ratios and 99% confidence intervals for demographic, socioeconomic, and household health characteristics associated COVID-19 incidence and mortality. Significant results are bolded and denoted by ** (p<0.01). IRRs reflect the risk associated with a 10% increase for variables expressed as a prevalence, a 100 people per square kilometer increase for population density, and a \$100 increase for median gross rent.