A Basic Demographic Profile of Workers in Frontline Industries

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Context

Before the COVID-19 pandemic, more than 30 million US workers were employed in six broad industries that are now on the frontlines of the response. They include grocery store clerks, nurses, cleaners, warehouse workers, and bus drivers, among others. They were essential before the pandemic hit, yet also overworked, underpaid, under protected, and underappreciated. The tables attached provide a basic demographic profile of workers in these frontline industries.

Table 1 shows the number of workers in six groups of frontline industries and the characteristics of the workforce in each of these industry groups. An accompanying spreadsheet provides state-level versions of Table 1. Additionally, New York state data are used in this report by the Fiscal Policy Institute.

Table 2 lists the specific industries within each of the six industry groups and shows the percentage of women workers, workers of color, and low-income workers in each of these industries.

Table 3 lists the top 10 occupations in each of the frontline industries and shows the percentage of women workers, workers of color, and low-income workers in each of these occupations.

At the national level, notable findings include:

- ***Workers in frontline industries are disproportionately women.*** About one-half of all workers are women, but nearly two-thirds (64.4 percent) of frontline workers are women. Women are particularly overrepresented in the frontline industries in Health Care (76.8 percent of workers) and Child Care and Social Services (85.2 percent). Women are also overrepresented in the following occupations within frontline industries: cashiers (71.8 percent); retail salespersons (63.5 percent); customer service representatives (63.7 percent); pharmacy technicians (81.6 percent); fast food and counter workers (67 percent); all of the top 10 occupations in the Health Care industry group (71.3 to 96.5 percent), except physicians; and, all of the top 10 occupations in the Child Care and Social Services industry group (73.1 to 97.7 percent).
- ***People of color are overrepresented in many occupations within frontline industries.*** Just over four-in-ten (41.2 percent) frontline workers are Black, Hispanic, Asian-American/Pacific Islander, or some category other than white. Hispanics are especially overrepresented in

Building Cleaning Services (40.2 percent of workers). Blacks are most overrepresented in Child Care and Social Services (19.3 percent of workers). Workers of color are particularly overrepresented in the following occupations: bus drivers, transit and intercity (56.7 percent); most of the top 10 occupations in Trucking, Warehouse, and Postal Service; most of the top 10 occupations in Building Cleaning Services; all of the top 10 occupations in Health Care, except registered nurses, physicians, managers, and secretaries and administrative; four of the top 10 occupations in Child Care and Social Services (childcare workers, personal care aides, social workers, and nursing assistants).

- ***Immigrants are overrepresented in Building Cleaning Services and in many frontline occupations in other frontline industries.*** About one-in-six frontline workers (17.3 percent) are immigrants. In Building Cleaning Services, 38.2 percent of workers are immigrants. Immigrant workers are also overrepresented in Grocery and Related Product Merchant Wholesalers (23.9 percent); Warehousing and Storage (22.5 percent), and Home Health Care Services (23.9 percent). Immigrants are particularly overrepresented in the following occupations: janitors and building cleaners (40.7 percent); maids and housekeeping cleaners (58.8 percent); cleaners of vehicles and equipment (34.5 percent); packers and packagers (39.1 percent); physicians (28.4 percent); and, home health aides (26.9 percent). A large share of personal care aids and nursing assistants in both the Health Care industry group and the Child Care and Social Services industry group are also immigrant workers (22.6 to 37.9 percent).
- ***Many workers in frontline industries are over age 50, and a substantial number live in a household with one or more older people.*** Just over one-in-three (33.9 percent) frontline workers are over age 50. Among all frontline workers, about one-in-six (16 percent) live with someone who is (or are themselves) over age 65.
- ***Many workers in frontline industries have family care obligations.*** More than one-third of frontline workers (35.9 percent) have a minor child at home.
- ***More than one-third of workers in many frontline industries live in low-income families.*** Roughly a third or more of low-income workers are found in six of the top 10 occupations in the Grocery, Convenience, and Drug Stores industry group; three of the top 10 occupations in the Trucking, Warehouse, and Postal Service industry group; four of the top 10 occupations in Building Cleaning Services industry group; three of the top ten occupations in the Health Care industry group; and, five of the top 10 occupations in the Child Care and Social Services industry group. Overall, almost one-quarter of frontline workers (23 percent) live in low-income families (income below 200 percent of poverty).
- ***The Building Cleaning Services industry has a particularly high incidence of uninsured workers.*** About one-in-ten frontline workers in this industry do not have health insurance. Among workers in Building Cleaning Services, nearly three-in-ten are uninsured.

While the COVID-19 legislation passed by Congress to date includes some important protections for frontline workers, these workers remain under protected and under compensated. Congress must act quickly on a variety of fronts to ensure that all frontline workers have: 1) comprehensive health insurance that includes free coverage of COVID-19 testing and treatment; 2) paid sick leave and paid family leave; 3) free child care; 4) student loan relief; and, 5) consumer and labor protections, including hazard pay or other additional compensation for essential workers. Frontline workers who are immigrants should be protected regardless of their current immigrant status. Finally, the US Occupational Safety and Health Administration should immediately issue an Emergency Temporary Standard requiring all employers to provide specific and necessary protections for frontline workers.

Methodology

This profile uses the most recent five-year estimates of data from the American Community Survey (2014–2018). The demographics of the frontline workforce is unlikely to have changed in any substantial way over the last two years, and using five-year estimates of ACS data helps ensure that sample sizes are sufficient to produce reasonably precise estimates by industry at the state level.

To define "frontline industries," we use the same six industry groupings as the New York City Comptroller did in their recent profile of frontline workers in New York City. The frontline industry groups, each of which includes one or more specific industries (as classified using the Census Bureau's Industry Codes), are:

- **Grocery, Convenience, and Drug Stores**: Grocery and related product merchant wholesalers (4470), Supermarkets and other grocery stores (4971), Convenience Stores (4972), Pharmacies and drug stores (5070), and General merchandise stores, including warehouse clubs and supercenters (5391).
- **Public Transit**: Rail transportation (6080) and Bus service and urban transit (6180).
- **Trucking, Warehouse, and Postal Service**: Truck transportation (6170), Warehousing and storage (6390), and Postal Service (6370).
- **Building Cleaning Services**: Cleaning Services to Buildings and Dwellings (7690).

- **Health Care**: Offices of physicians (7970), Outpatient care centers (8090), Home health care services (8170), Other health care services (8180), General medical and surgical hospitals, and specialty hospitals (8191), Psychiatric and substance abuse hospitals (8192), Nursing care facilities (skilled nursing facilities) (8270), and Residential care facilities, except skilled nursing facilities (8290).
- **Child Care and Social Services**: Individual and family services (8370), Community food and housing, and emergency services (8380), and Child day care services (8470).

Our initial analysis includes all US workers in these six frontline industry categories, but no workers in frontline occupations that are outside of these six categories. As a result, our estimates exclude some workers in occupations (but not industries) that are clearly on the frontlines, while also including some workers who are not in frontline occupations, even though they are in frontline industries. For example, a police officer is a frontline occupation in a non-frontline industry, while a school bus driver is a non-frontline occupation (at least in areas where schools are closed) in a frontline industry (public transit). Still, the vast majority of workers in the six frontline industries are frontline workers.

Table 1

Characteristics of Workers in Frontline Industries

	All Workers	All Frontline Industries	Grocery, Convenience, and Drug Stores	Public Transit	Trucking, Warehouse, and Postal Service	Building Cleaning Services	Health Care	Child Care and Social Services
All Workers (16+)	152,600,169	31,673,098	6,817,890	804,495	3,128,922	1,484,993	16,103,877	3,332,921
Female	47.4%	64.4%	50.5%	29.1%	22.7%	53.2%	76.8%	85.2%
Full/Part-time								
Full-time	78.6%	75.3%	63.7%	81.0%	90.5%	62.6%	79.8%	67.4%
Part-time	21.4%	24.7%	36.3%	19.0%	9.5%	37.4%	20.2%	32.6%
Race/Ethnicity								
White	63.5%	58.8%	59.5%	54.7%	56.4%	43.4%	61.1%	55.8%
Black	11.9%	17.0%	14.2%	26.0%	18.2%	12.6%	17.5%	19.3%
Hispanic	16.8%	16.3%	18.5%	14.0%	20.0%	40.2%	12.1%	18.0%
AAPI	6.6%	6.7%	6.6%	4.1%	4.2%	2.4%	8.0%	5.3%
Other	1.2%	1.2%	1.3%	1.2%	1.1%	1.3%	1.2%	1.5%
Foreign Born	17.1%	17.3%	15.7%	15.2%	17.9%	38.2%	16.2%	17.0%
Education Level								
LTHS	9.3%	8.5%	13.0%	6.9%	12.7%	26.5%	4.3%	7.9%
HS	24.5%	25.8%	36.0%	38.1%	42.6%	38.5%	17.2%	21.7%
Some college	32.0%	36.3%	35.2%	39.4%	34.2%	26.0%	38.2%	34.7%
College	21.6%	18.1%	11.9%	11.4%	8.7%	7.4%	22.8%	22.9%
Advanced	12.6%	11.4%	4.0%	4.1%	1.8%	1.5%	17.5%	12.8%
Age 50+	33.1%	33.9%	27.4%	46.7%	40.2%	35.6%	34.6%	34.4%
Home Ownership	65.3%	63.6%	59.6%	68.2%	65.5%	50.0%	66.7%	60.1%
Public Transit Commute to Work	5.1%	4.8%	4.5%	9.0%	2.4%	7.8%	4.6%	6.8%
Compensation and Benefits								
Below poverty line	6.7%	7.2%	10.0%	4.5%	4.7%	15.9%	5.2%	10.8%
<200% poverty line	20.6%	23.0%	30.1%	16.0%	19.2%	42.4%	17.8%	30.0%
No health insurance	11.0%	9.9%	12.1%	5.8%	14.8%	29.1%	6.3%	10.4%
Family Responsibilities								
Child in home	35.8%	35.9%	33.9%	32.6%	33.3%	38.8%	36.9%	36.9%
Senior (age 65+) in home	14.8%	16.0%	16.8%	18.4%	14.9%	15.5%	15.3%	18.5%

Source: CEPR's Analysis of American Community Survey, 2014-2018 5-Year Estimates

Table 2

Workers in Detailed Frontline Industries

	Number of Workers	Share of Workers in Frontline Industries	Female	Non-White	Foreign Born	<200% Poverty Line
All Frontline Industries	31,673,098	100.0%	64.4%	41.2%	17.3%	23.0%
Grocery, Convenience, and Drug Stores						
Grocery and Related Product Merchant Wholesalers	813,907	2.6%	26.1%	45.1%	23.9%	20.6%
Supermarkets and Other Grocery (Except Convenience) Stores	2,663,280	8.4%	47.6%	38.5%	16.1%	31.2%
Convenience Stores	338,590	1.1%	58.2%	37.5%	15.5%	33.8%
Pharmacies and Drug Stores	925,336	2.9%	65.6%	37.5%	15.1%	22.7%
General Merchandise Stores, Including Warehouse Clubs and Supercenters	2,076,777	6.6%	55.9%	43.0%	12.3%	35.2%
Public Transit						
Rail Transportation	255,253	0.8%	10.0%	26.2%	6.0%	6.3%
Bus Service and Urban Transit	549,242	1.7%	38.0%	54.2%	19.5%	20.6%
Trucking, Warehouse, and Postal Service						
Truck Transportation	1,832,391	5.8%	12.3%	38.2%	18.2%	18.7%
Postal Service	678,084	2.1%	43.0%	43.8%	12.8%	9.8%
Warehousing and Storage	618,447	2.0%	31.4%	59.2%	22.5%	31.1%
Building Cleaning Services						
Services to Buildings and Dwellings (Except Cleaning During Construction and Immediately After Construction)	1,484,993	4.7%	53.2%	56.6%	38.2%	42.4%
Health Care						
Offices of Physicians	1,740,382	5.5%	77.2%	30.2%	13.8%	12.4%
Outpatient Care Centers	1,633,127	5.2%	77.3%	36.8%	12.9%	15.1%
Home Health Care Services	1,368,990	4.3%	87.5%	53.0%	23.9%	38.6%
Other Health Care Services	1,126,466	3.6%	66.4%	40.8%	16.5%	16.1%
General Medical and Surgical Hospitals, and Specialty (Except Psychiatric and Substance Abuse) Hospitals	7,210,512	22.8%	75.0%	36.4%	15.7%	10.9%
Psychiatric and Substance Abuse Hospitals	97,814	0.3%	63.1%	40.0%	15.1%	11.6%
Nursing Care Facilities (Skilled Nursing Facilities)	1,842,045	5.8%	84.2%	44.6%	17.7%	30.7%
Residential Care Facilities, Except Skilled Nursing Facilities	1,084,541	3.4%	74.3%	42.8%	15.4%	31.2%
Child Care and Social Services						
Individual and Family Services	1,630,740	5.1%	78.1%	45.5%	17.5%	25.9%
Community Food and Housing, and Emergency Services	142,591	0.5%	64.2%	43.9%	11.1%	27.0%
Child Day Care Services	1,559,590	4.9%	94.6%	43.0%	17.0%	34.5%

Source: CEPR's Analysis of American Community Survey, 2014-2018 5-Year Estimates

Table 3

Top 10 Occupations in Frontline Industries

(percent)

	Share of Workers in Frontline Industries	Female	Non-White	Foreign Born	<200% Poverty Line
Grocery, Convenience, and Drug Stores	100.0%				
Cashiers	18.3%	71.8%	44.6%	14.4%	42.7%
First-Line Supervisors of Retail Sales Workers	14.3%	49.4%	34.0%	13.4%	21.2%
Stockers and Order Fillers	11.1%	30.3%	43.9%	13.5%	35.9%
Retail Salespersons	7.0%	63.5%	42.5%	15.8%	35.6%
Laborers and Freight, Stock, and Material Movers, Hand	6.5%	25.6%	42.1%	14.0%	32.4%
Customer Service Representatives	4.2%	63.7%	41.2%	12.7%	35.6%
Driver/Sales Workers and Truck Drivers	2.9%	4.4%	43.1%	19.6%	18.5%
Pharmacists	2.7%	54.7%	31.8%	22.0%	7.5%
Pharmacy Technicians	2.6%	81.6%	38.3%	12.4%	27.0%
Fast Food and Counter Workers	2.0%	67.0%	34.2%	11.4%	42.5%
Public Transit	100.0%				
Bus Drivers, School	19.2%	48.3%	51.8%	17.5%	25.6%
Bus Drivers, Transit and Intercity	18.6%	30.7%	56.7%	19.8%	22.3%
Railroad Conductors and Yardmasters	5.8%	6.6%	27.8%	4.2%	5.3%
Locomotive Engineers and Operators	5.3%	3.0%	23.2%	3.6%	4.0%
Bus and Truck Mechanics and Diesel Engine Specialists	3.2%	2.7%	41.8%	19.9%	8.1%
Supervisors of Transportation and Material Moving Workers	3.1%	20.1%	42.2%	12.9%	6.0%
Other Managers	2.4%	24.7%	29.8%	11.9%	6.0%
Other Rail Transportation Workers	2.4%	10.2%	40.4%	12.0%	9.8%
Driver/Sales Workers and Truck Drivers	2.4%	25.2%	51.8%	18.6%	21.3%
Heavy Vehicle and Mobile Equipment Service Technicians and Mechanics	2.1%	2.6%	27.6%	8.3%	7.5%
Trucking, Warehouse, and Postal Service	100.0%				
Driver/Sales Workers and Truck Drivers	42.3%	4.4%	40.9%	20.4%	18.3%
Postal Service Mail Carriers	10.4%	40.1%	37.5%	11.3%	10.3%
Laborers and Freight, Stock, And Material Movers, Hand	7.3%	14.9%	60.4%	19.4%	35.6%
Postal Service Clerks	3.6%	54.7%	52.8%	16.4%	9.1%
Industrial Truck and Tractor Operators	3.0%	7.5%	63.7%	21.0%	29.9%
Other Managers	2.6%	34.8%	27.4%	10.7%	9.7%
Postal Service Mail Sorters, Processors, And Processing Machine Operators	2.1%	50.0%	58.3%	16.0%	10.9%
Stockers and Order Fillers	1.8%	36.8%	55.4%	17.4%	32.7%
Packers and Packagers, Hand	1.8%	55.9%	80.8%	39.1%	49.1%
Bus and Truck Mechanics and Diesel Engine Specialists	1.5%	0.8%	27.6%	13.1%	20.8%
Building Cleaning Services	100.0%				
Janitors and Building Cleaners	44.7%	50.7%	62.5%	40.7%	47.3%

Maids and Housekeeping Cleaners	23.7%	90.7%	69.8%	58.8%	57.1%
First-Line Supervisors of Housekeeping and Janitorial Workers	8.9%	36.0%	45.0%	26.4%	25.6%
Pest Control Workers	5.2%	4.7%	30.7%	8.7%	23.4%
Other Installation, Maintenance, and Repair Workers	2.9%	6.6%	35.5%	21.4%	29.6%
Laundry and Dry-Cleaning Workers	1.7%	7.4%	43.0%	19.9%	34.9%
Secretaries and Administrative, Except Legal, Medical, and Executive	1.0%	93.5%	29.0%	10.5%	20.5%
Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	0.8%	19.0%	18.8%	5.7%	13.6%
Other Managers	0.6%	33.7%	43.4%	20.9%	14.8%
Cleaners of Vehicles and Equipment	0.6%	24.6%	56.6%	34.5%	39.5%
Healthcare	100.0%				
Registered Nurses	17.7%	88.9%	29.4%	15.8%	4.9%
Nursing Assistants	8.5%	88.7%	56.7%	22.6%	41.5%
Physicians	5.0%	37.5%	35.4%	28.4%	2.1%
Licensed Practical and Licensed Vocational Nurses	4.7%	87.9%	44.6%	14.3%	20.5%
Personal Care Aides	4.5%	83.9%	56.4%	23.3%	49.0%
Medical and Health Services Manager	3.7%	71.3%	29.9%	12.3%	5.2%
Medical Assistants	2.9%	91.7%	50.1%	15.3%	26.8%
Home Health Aides	2.7%	89.9%	59.9%	26.9%	44.3%
Secretaries and Administrative, Except Legal, Medical, and Executive	2.4%	95.6%	31.8%	9.3%	14.7%
Receptionists and Information Clerks	2.3%	94.8%	39.9%	10.4%	25.5%
Child Care and Social Services	100.0%				
Childcare Workers	22.8%	95.0%	44.8%	21.0%	38.8%
Preschool and Kindergarten Teachers	13.9%	97.7%	38.0%	11.9%	32.2%
Personal Care Aides	11.6%	82.9%	56.2%	29.7%	47.2%
Social Workers All Other	6.6%	82.8%	43.8%	10.9%	12.7%
Social and Community Service Managers	4.3%	73.1%	34.0%	10.0%	10.1%
Teaching Assistants	3.2%	96.8%	48.3%	17.1%	37.9%
MGR-Education and Childcare Administrat	2.6%	93.1%	37.4%	10.0%	14.5%
Receptionists and Information Clerks	2.3%	79.1%	51.3%	13.7%	25.9%
Nursing Assistants	1.6%	90.2%	62.9%	37.9%	45.7%
Educational, Guidance, and Career Counselors and Advisors	1.6%	75.0%	34.8%	8.4%	15.6%

Source: CEPR's Analysis of American Community Survey, 2014-2018 5-Year Estimates

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Rhea Co. farm leader says all of their nearly 200 employees have virus, only 3 symptomatic

by Sam Luther
Tuesday, May 26th 2020

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Southern Valley Executive Officer John Schwalls says 100 percent of the workforce at Henderson Farm - nearly 200 employees total - has contracted COVID-19. (Image: WTVC)

RHEA COUNTY, Tenn. — We're now learning new details about the farm that's behind a massive coronavirus outbreak in Rhea County.

Henderson Farm in Evensville has been the center of a COVID-19 outbreak, causing the county's cases to jump from 13 to almost 200, but the executive officer of Southern Valley - a partner of the farm - tells us the infection has been contained.

m Luther's 6pm report here.

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Schwalls says that only three employees - less than 1% of the workforce - have shown symptoms, in the nearly 200 employees that have the virus.

Sam Luther @SamLuther_ · May 26, 2020
Replying to @SamLuther_
John Schwalls says that employees stay in an air conditioned "college dorm like room with bunk beds." And that since the first case confirmed on May 11th, nobody has left the farm and gone into the public

Sam Luther
@SamLuther_

He tells me that right now everybody is asymptomatic and still working, but the farm has offered to pay employees even if they can't work. Schwalls says anybody is free to come and go saying, "we're not running a concentration camp."

4:20 PM · May 26, 2020

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case of COVID-19 was confirmed in the farm on May 11th. Schwalls says every employee was

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ultimately only three people were symptomatic with a cold-like illness, every single employee tested positive for the virus.

Since this happened, Schwalls says no employee has left the Henderson Farm area, and that supplies have been brought to those that reside there. The company’s executive officer says that there’s been a big misconception from Rhea County residents that Hispanic people in the community are contagious, when in fact none of those workers have been in local stores or restaurants.

When we asked Schwalls if those people could freely leave the farm he says, “this isn’t a concentration camp, people can come and go.” But he says that although they have the ability to leave, nobody has because of their own concerns and worry.

(Image: WTVC)

Schwalls tells us that all the employees are still working, even with the virus. "I can't make ie not work or work," he said.

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monitoring the situation, and have someone with the department specifically designated to monitor symptoms and cases as they develop at the farm.

As of May 26, the state health department reports 197 cases of coronavirus in Rhea County.

On Monday, Henderson Farms released the following statement to us:

> *"After a worker tested positive for COVID-19 and out of an abundance of caution, we requested that the Rhea County Health Department test all employees at Henderson Farms in Evensville, TN. When the results came back, we learned our workers at this location tested positive for COVID-19. At this stage, we feel blessed that our workers are asymptomatic and the situation remains contained. Yet as a precautionary measure and in line with the latest public health guidelines, these workers continue to remain in isolation at the farm where they live and work. Nothing is more important to us than the health of our workers and community at large. We take this very seriously and are monitoring the situation closely in partnership with Rhea County Health Department, taking all precautionary measures to continue to protect our workers and our community."*

This is a developing story.

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Coronavirus

Inside Green Empire Farm: Upstate NY's biggest coronavirus outbreak slams migrant workers

Updated May 08, 2020; Posted May 08, 2020

Scott Trimble |

By Marnie Eisenstadt | meisenstadt@syracuse.com

Oneida, N.Y. — Every day, more than 300 workers walked in and out of the sprawling Green Empire Farm greenhouse on the edge of the city of Oneida.

Even when the whole world mostly shut down, the 32-acre farm under glass kept going. There were millions of strawberries to pick after growing ripe under miles of glass. And there were half a million tomato plants to tend.

The company, Mastronardi Produce of Canada, took measures to protect those workers from the coronavirus, officials from Madison County and the company said.

But it didn't matter. At the end of each workday, 186 workers left the giant farm in vans and on buses, to return to hotels where they lived four to a room and slept two to a bed.

The workers' living conditions, chosen for them by the labor company that hired them and brought them to Oneida, were perfect for the coronavirus to dig in and take hold.

And it did.

The indoor farming complex is now the site of the biggest coronavirus cluster in Upstate New York, according to Gov. Andrew Cuomo's office. The only cluster outside of New York City that was bigger was in New Rochelle.

By Thursday, 169 of the 340 workers had tested positive.

"They were living in close quarters, together, so it was ripe for spread," said Eric Faisst, Madison County public health director. "The conditions were perfect."

The farmworkers living in the hotels are migrant workers who speak little English, county officials said.

Faisst said many of the workers are scared. They came here to the U.S. to work and send money to their families. Some are from Mexico and other Spanish-speaking countries, others are from Haiti. Now they are stuck: They can't work, and they can't go home.

The county had to get 12 interpreters to help with tracing the sick and exposed workers' travels through the area.

The outbreak was so shocking that it caught Cuomo's attention. He mentioned it in his nationally viewed
…s the nation.

“It’s when you run a facility with a large number of workers in a dense environment,” the governor said.

But county officials say it’s not the workplace, but where the workers live that have been making them worry since the pandemic started.

Until last April 29, it seemed like everything was under control. That’s when Faisst got the first bad news: The night before, Oneida Health, the hospital nearest the greenhouse, saw two workers.

Both were sick with COVID-19. Both lived in those hotels, four to a room. Workers live in the Super 8 and the Days Inn in Madison County and the La Quinta Hotel in Verona in Oneida County.

When Faisst heard of about the two positive tests among the workers, he knew he was facing a potential cluster that showed the virus’ ability to jump from person to person at an exponential rate. All the farmworkers, migrant and local, had to be tested.

The county called in the state for help. Two days later, an army of state and county workers set up rows inside the greenhouse.

The farmworkers filed in, speaking to each other in Spanish and French. One by one, nurses swabbed their noses and took down their contact information, aided by interpreters. Then the workers boarded the buses and vans back to the hotels to wait.

By Monday, the results came back. All but 47 of the contract workers had the virus.

The county and state tested the second wave of workers, mostly local help, on Tuesday in the same way. That turned up 31 more positives.

Part of the Flavor Army

All of the workers at the farm do the same jobs and make roughly the same pay on paper, employees said. But they live in two different worlds and work for two different employers.

The workforce drawn from Central New York makes a little less than $13 an hour. They pick, plant, sort and pack. They work for Green Empire Farm, which is owned by Mastronardi Produce, a 70-year-old company in Kingsville, Ontario, that was started by an Italian immigrant who decided to grow hothouse tomatoes. The company has at least six hothouse farms in North America.

Most of the produce is sold under the Sunset brand. The new amphitheater in the company’s hometown bears its name: Sunset Stadium.

The company prides itself on how it treats its workers, a company spokeswoman said, and is devastated about the outbreak at the new farm in Oneida.

Mastronardi calls its workers the “Flavor Army.”

But more than half the workers in Oneida, those in the buses and the hotels, are migrant farmworkers employed by an Indiana company called MAC Contracting. A Mastronardi spokeswoman said MAC supplies workers to many of the company’s greenhouses.

Faisst said the contract workers did not bring the virus into the community. The county’s first coronavirus case was at the greenhouse, but it was a local worker.

A worker who has been at the greenhouse since it opened said the migrant workers were hired to take local

less than $13

hotel rooms.

Since the outbreak, the county has been pushing MAC to put fewer workers in the rooms and to pay them when they're not working, said John Becker, chairman of the Madison County Board of Supervisors.

"You're going to comply, or we'll take further measures," Becker said the county told MAC.

He said he was "aghast" when he found out how many workers were living in a room, together, while public health officials were trying to space people six feet apart.

Becker said he was concerned the workers would not be paid when they were quarantined, which made him worry they would keep working while they were sick.

The county, he said, pushed Mastronardi to pay them while sick. Becker said the county is delivering food to all of the workers in the hotels in Madison County while they are quarantined to keep them inside. It is costing the county $3,000 a day.

Becker said the outbreak is peeling back the curtain on how factory farms work.

"We can't fill the jobs with American labor, so these folks come up. They send money home. These conditions are throughout the country," said Becker, who ran his family's dairy farm for decades.

'We followed social distancing'

Becker said it's unclear whether the workers have the documents to work in the U.S.

"That's one of those questions I don't want to ask," he said. "That's MAC's deal."

Farm labor contractors, like MAC, traditionally handle the certifying that the workers' papers are legal for the companies that hire them. They also handle transportation and housing.

The Oneida greenhouse had always planned to bring in some labor. There is a bunkhouse on the grounds, but it's not finished.

The greenhouse just opened in August. It took five years of work to get the farm to come to Madison County, Becker said. The county was jockeying with others to get the huge operation. In the end, Madison County had the most land and the sweetest deal: a 20-year tax break worth millions.

Company documents show that the project will be built in four phases on 600 acres of land. Each phase is a 32-acre greenhouse. The total cost is more than $100 million. It's unclear how much of the project has been completed.

Cris Schultz, a MAC employee in Indiana, disputed the county's account in an interview Thursday with syracuse.com. She said the workers never stayed more than three to a room. She said the workers pay for some of the housing out of their paychecks, but she would not say how much.

She disputed that the workers' living arrangements made them ill.

"Everyone is entitled to their own opinion," Schultz said. "We followed social distancing."

She declined to say how MAC helped the workers follow social distancing when they were on the buses or at the hotels. County officials said that, after prodding, MAC spaced the workers out on the buses and vans and began wiping down the vehicles several times a day.

Schultz would not say how many workers were sick with symptoms from the virus. At one point in she said
…een
…iving in.

“I am worried about them, their health,” Schultz said. Then she hung up.

“They came here to work”

Oneida feels more like a village than a city. The population is 11,000. People mostly know each other, and now they know the workers who have been picking and planting under the glass at the edge of the city.

The outbreak has put a spotlight on the laborers in a way that makes county and city officials worry.

“They came here to work and send money back to their country,” said Oneida Mayor Helen Acker. “They want to work; they don’t want to be sick.”

Now they are being watched, not just by public health officials, but by people who are angry they are here. Madison County publicly identified nine local businesses, including a laundromat and the Walmart, as places the farmworkers frequented.

Faisst said he feels the virus is under control. The workers have been tested and quarantined. He is not worried about them spreading the virus.

“They’re scared as hell and then on top of that, you’re starting to see this mob mentality. They’re victims of this virus … they acquired this here,” Faisst said. “My concern is for their safety.”

None of the county officials thought the greenhouse would be closed.

All of migrant workers have been isolated in their hotels since the mass testing last Saturday.

The infected workers will be released in roughly two weeks.

Workers who have recovered and workers who tested negative will be back at work sooner.

Next week they will be picking the millions of tomatoes under acres of glass at the edge of the city.

Do you work for Green Empire Farm in Oneida or know about the handling of its workforce? Reporter Marnie Eisenstadt would like to talk to you. Contact her anytime: email | twitter| Facebook | 315-470-2246

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Of the 5 States with the Most Farmworkers, Only 3 Are Prioritizing Vaccines — and Not All Means of Prioritizing Are Equal, per the CDC

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Above, a scene from the July 2020 documentary "COVID's Hidden Toll." Months later, FRONTLINE found that only some states are prioritizing farmworkers, deemed an essential workforce, for vaccines.

APRIL 16, 2021

by · Paula Moura (https://www.pbs.org/wgbh/frontline/person/paula-moura/)

On a recent Saturday morning, Karla, a farmworker from Mexico, didn't wake up early to weed fields around Morrow County, Oregon. Instead, she went to a regional tourism center to get her first dose of the COVID-19 vaccine.

"It took a weight off my shoulders," she said. Karla came to the U.S. in February to find work and to save money for her son, who just started college. "I went there because they didn't ask for documents," Karla said of the tourism center. She was afraid a local clinic might ask for information that immigration authorities could use to track her.

Karla is one of 2.4 million farmworkers in the U.S. — at least half of whom are undocumented, according to the U.S. Department of Agriculture, and all of whom should be prioritized for COVID-19 vaccines, according to the Centers for Disease Control and Prevention (CDC).

What's more, the CDC recommends (https://www.cdc.gov/mmwr/volumes/69/wr/mm695152e2.htm) that vaccinations for farmworkers be offered near their worksites or in their communities. "Minimizing barriers to access vaccination for frontline essential workers, such as vaccine clinics at or close to the place of work, are optimal," the CDC statement (https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/covid-19/evidence-table-phase-1b-1c.html) said. The agency included all agricultural workers in phase 2 of its vaccine-priority recommendations, along with police officers, to "preserve functioning of society."

Despite the CDC's guidance, only three of the five states with the most farmworkers, according to the U.S. Census Bureau — California, Washington and Oregon — prioritized farmworkers for vaccinations ahead of the general population. And only two — California and Oregon — have established policies that provide vaccination clinics for farmworkers on worksites or in their communities.

Texas and Florida did not prioritize vaccinations for farmworkers ahead of the general population. And although officials from Washington and Texas said they were targeting or planning to target farmworkers, neither has issued a state policy prioritizing vaccine events on farms or in farmworker communities._

In states lacking aggressive vaccination campaigns, farmworkers — deemed "essential" to the nation's food supply by the Trump administration (https://www.cisa.gov/sites/default/files/publications/CISA-Guidance-on-Essential-Critical-Infrastructure-Workers-1-20-508c.pdf) and reaffirmed by President Joe Biden (https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/18/statement-by-president-biden-on-the-farm-workforce-modernization-act-of-2021/) — are again at risk of COVID-19 outbreaks.

"Without true access to vaccination, I fear that we will see a dramatic increase in COVID-19 mortality … as the harvest season ramps up, similar to 2020," sociologist Alicia Riley told FRONTLINE. Riley coauthored a University of California San Francisco study (https://www.medrxiv.org/content/10.1101/2021.01.21.21250266v1.full) published in January that found the mortality rate among farmworkers increased 55% from March through September 2020, compared to the same period in previous years.

In total, some 9,100 farmworkers have died of COVID-19 in the U.S. since the beginning of the pandemic, out of 554,000 infections, according to Jayson Lusk, a professor of agricultural economics at Purdue University.

That grim death toll has repercussions beyond the workers themselves. "It's not just the workforce. It's their families, because we know that they live in overcrowded living conditions," said Dr. Max Cuevas. Featured prominently in the July 2020 FRONTLINE documentary *COVID's Hidden Toll,* Cuevas is the CEO of Clinica de Salud del Valle de Salinas, which has been at the center of vaccine distribution in California's Monterey County.

"Without those workers, we don't eat," he said.

With Targeted Clinics

Oregon — which the U.S. Census Bureau estimates has around 86,000 farmworkers — began prioritizing vaccines for farmworkers on March 29, ahead of all adults becoming eligible May 1. At the first state-held event targeting farm- and food-processing workers in late March, some 1,000 people in Morrow County were vaccinated.

"They were suggesting that folks schedule an appointment ahead of time, but they were also welcoming walk-ins. That's a really beneficial option," said Zaira Sanchez, emergency relief coordinator for the farmworker-focused nonprofit UFW Foundation, which helped organize the event. "Some folks just don't have access or skills to navigate online registration systems."

The next step is coordinating with the state to bring mobile vaccination clinics to farms, Sanchez said. "We are hoping that, doing mobile clinics on worksites, we are getting to the folks who don't have time or don't have the ability to travel to their appointment or to the event."

Beyond improving access and eliminating the need to take time off work or to register online, on-site events give clinicians the chance to thoroughly explain the importance and safety of vaccinations.

"Delivery of these services by trusted entities is important, given the mistrust, as well as misunderstanding, around COVID and vaccines in general," said Brenda Eskenazi, the director of the Center for Environmental Research and Children's Health at University of California Berkeley, who tracked COVID-19 infections among farmworkers in California's Salinas Valley.

Even so, many are wary. At an April 3 event organized by LUPE, a farmworker union, targeting agricultural workers in Texas' Rio Grande Valley, clinicians successfully delivered about 700 vaccinations, but "Half of the people we were asking said, 'No, thanks,'" said Daniel Diaz, LUPE's director of organizing.

Texas — which has 143,763 farmworkers, according to the U.S. Census Bureau — now has the second highest COVID-19 infection rate in the country, after California.

Maria, a 39-year-old farmworker in the Rio Grande Valley, said she is hesitant to get vaccinated because she has lingering side effects from a previous bout with COVID-19: "I want to see what happens to others."

Without Targeted Clinics

To date, vaccine rollout for the general U.S. population has bested the Biden administration's initial timeline, but that has not been true for people of color, including undocumented workers. Advocates worry that, as states open up vaccines to all adults, farmworkers will be locked out. And vaccinating now is critical, many told FRONTLINE, because the peak agricultural season starts soon.

And yet, many farmworkers have avoided offsite vaccinations due to fear of providing information that could be used to deport them. While a social security number or a state-issued ID is not required to receive a shot, none of the five states with the largest numbers of farmworkers issued guidelines to vaccinators, instructing them not to request this information.

In a statement (https://www.dhs.gov/news/2021/02/01/dhs-statement-equal-access-covid-19-vaccines-and-vaccine-distribution-sites), the Department of Homeland Security said it won't perform raids on vaccination sites and "encourages all individuals, regardless of immigration status, to receive the COVID-19 vaccine." The CDC (https://www.cdc.gov/coronavirus/2019-ncov/vaccines/keythingstoknow.html?s_cid=10499:about%20covid%2019%20vaccine:sem.ga:p:RG:GM:gen:PTN:FY21) said vaccines are "free of to all people living in the United States, regardless of their immigration or health insurance status."

And yet, 14 people in Texas were denied vaccines at a University of Texas Rio Grande Valley (UTRGV) clinic, near the border with Mexico. A LUPE report (https://lupenet.org/2021/04/12/report-inequitable-vaccine-access-for-undocumented-people-in-the-rgv/?tl_inbound=1&tl_groups%5b0%5d=10212&tl_form_type=1&tl_period_type=3&emci=a4d45130-659c-eb11-85aa-0050f237abef&emdi=53429f0c-689c-eb11-85aa-0050f237abef&ceid=837127) released April 12 found that, out of 20 private providers in the state's Cameron, Hidalgo and Starr counties, four asked for social security numbers or a Texas ID to register for vaccinations. UTRGV ultimately issued an apology, and the 14 were vaccinated.

By contrast, Colorado (https://www.denverpost.com/2021/01/17/colorado-covid-vaccine-undocumented-noncitizens/), which has around 36,733 farmworkers, issued a letter advising providers not to request IDs and threatening to cut vaccine access if they did.

In Florida — which has 96,247 farmworkers, according to the Census Bureau — many people don't want the vaccine, because they don't think it's safe, said Maria Martinez, a coordinator with the nonprofit Farmworker Association of Florida.

Most of the state's farmworkers weren't eligible for vaccines until April 5, along with the general population. In the meantime, Martinez said, farmworkers were "harvesting potatoes and planting chili, tomatoes. They are working. Despite bringing their mask, they are still close to each other at work."

The Florida Department of Health didn't respond to questions from FRONTLINE.

Challenges Remain

Even with worksite events, it's hard to reach everyone — or to avoid line jumpers. "In the initial rollout, clearly there were some disparities: a lot of confusion, a lack of transparency about who was receiving the vaccine and why," said California State Assembly member Robert Rivas (D-30), who emphasized the need for workplace safety measures in *COVID's Hidden Toll.*

Together with nonprofits and mobile clinics, California has delivered more than 15,000 vaccine doses to farmworkers and has allocated 40,000 doses for food and farmworkers. But that covers a fraction of the state's 1 million farmworkers, as estimated by the state's Department of Public Health.

At the rate Monterey County is presently receiving vaccines from the state, it would take six more weeks to fully vaccinate farmworkers — "and that's only one of the groups that currently are eligible for the vaccine," said Jimenez of the county's Health Department.

All of this is before California's peak harvest begins in late April. As the high season moves across the U.S., it brings an influx of new migrants, who travel through Arizona, California, Michigan and beyond.

Leticia, a 35-year-old fruit picker who lives on the outskirts of Prosser, Oregon, is concerned about more unvaccinated workers arriving. Getting sick would affect her ability to feed her kids.

"They say we are essential workers, but they don't give us the same rights. If we are not protected, we will keep working, with the virus or not," she said. "We can't stop and we can't stay home."

Watch COVID's Hidden Toll (https://www.pbs.org/wgbh/frontline/film/covids-hidden-toll/) *in its entirety below.*

This story has been updated to include the name of Morrow County.

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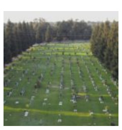

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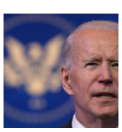

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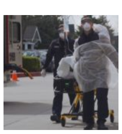

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Excess mortality associated with the COVID-19 pandemic among Californians 18–65 years of age, by occupational sector and occupation: March through October 2020

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Abstract

Background

Though SARS-CoV-2 outbreaks have been documented in occupational settings and though there is speculation that essential workers face heightened risks for COVID-19, occupational differences in excess mortality have, to date, not been examined. Such information could point to opportunities for intervention, such as workplace modifications and prioritization of vaccine distribution.

Methods and findings

Using death records from the California Department of Public Health, we estimated excess mortality among Californians 18–65 years of age by occupational sector and occupation, with additional stratification of the sector analysis by race/ethnicity. During the COVID-19 pandemic, working age adults experienced a 22% increase in mortality compared to historical periods. Relative excess mortality was highest in food/agriculture workers (39% increase), transportation/logistics workers (28% increase), facilities (27%) and manufacturing workers (23% increase). Latino Californians experienced a 36% increase in mortality, with a 59% increase among Latino food/agriculture workers. Black Californians experienced a 28% increase in mortality, with a 36% increase for Black retail workers. Asian Californians experienced an 18% increase, with a 40% increase among Asian healthcare workers. Excess mortality among White working-age Californians increased by 6%, with a 16% increase among White food/agriculture workers.

Conclusions

Certain occupational sectors have been associated with high excess mortality during the pandemic, particularly among racial and ethnic groups also disproportionately affected by COVID-19. In-person essential work is a likely venue of transmission of coronavirus infection and must be addressed through strict enforcement of health orders in workplace settings and protection of in-person workers. Vaccine distribution prioritizing in-person essential workers will be important for reducing excess COVID mortality.

Introduction

More deaths are occurring during the COVID-19 pandemic than predicted by historical trends [1-4]. In California, per-capita excess mortality is relatively high among Blacks, Latinos, and individuals with low educational attainment [4]. An explanation for these findings is that these populations face unique occupational risks because they may disproportionately make up the state's essential workforce and because essential workers often cannot work from home [4-6]. Additionally, due to historical structural inequities, low-wage essential workers may be more likely to live in crowded housing [5-7], resulting in household transmission.

Despite the inherent risks that essential workers face, no study to date has examined differences in excess mortality across occupation. Such information could point to opportunities for intervention, such as workplace modifications and prioritization of vaccine distribution. Using time-series models to forecast deaths from March through October 2020, we compare excess deaths among California residents 18–65 years of age across occupational sectors and occupations, with additional stratification of the sector analysis by race/ethnicity.

Methods

We obtained data from the California Department of Public Health on all deaths occurring on or after January 1, 2016.

To focus on individuals whose deaths were most plausibly linked to work, we restricted our analysis to decedents 18–65 years of age. Death certificates include an open text field for "Decedent's usual occupation," described as "type of work done during most of working life." Retirement is not separately recorded. We processed the occupation information listed on the death certificates using an automated system developed by the National Institute for Occupational Safety and Health, which converts free-text occupational data to 2010 US Census codes. A team of 3 researchers manually categorized the resulting 529 unique codes into occupational sectors, with a focus on the 13 sectors identified by Cailfornia officials as comprising the state's essential workforce[8] and retail workers; we anticipated that these sectors would be most at risk. To ease presentation, we combined or eliminated some sectors, placing the defense, communications/IT, and financial sectors in the not-essential category (under the logic that it was particularly difficult to ascertain which workers in these sectors fully met the state's definitions for essential work) and placing chemical, energy, and water sectors in the facilities category. This resulted in the following 9 groups: facilities, food/agriculture, government/community, health/emergency, manufacturing, retail, transportation/logistics, not essential, and unemployed/missing. We defined 4 racial/ethnic groups: Asian, Black, Latino, and White, with the definition of Latino overwriting any racial designation in the death records. Our definition of Asian, Black, and White excludes individuals identified on the death certificate as multiracial.

We defined pandemic time as beginning on March 1, 2020. In some time-stratified analysis, we compared the months of March through May to the months of June and July. We chose the cutoff of June 1 because it is roughly 3 weeks after the state's post-shutdown reopening in early May, and because we anticipate lags between policy, infection, and death. Similarly, the ending date of July 31 is roughly 3 weeks after the state ordered restaurants and indoor businesses to close in early July.

We conducted time-series analysis for each occupational sector, with additional stratification by race/ethnicity. For each group of interest (for example, each occupational sector of interest), we repeated the following procedure. We aggregated the data to months or weeks, using the weekly analysis for visualizations and the monthly analysis to derive summary measures. Following our previous work [4], we fit dynamic harmonic regression models with autoregressive integrated moving average (ARIMA) errors for the number of monthly/weekly all-cause deaths, using deaths occurring among the group prior to March 1, 2020. For each iteration, we used a model-fitting procedure described by Hyndman and Khandakar [9]. Using the final model, we forecast the number of deaths for each unit of time, along with corresponding 95% prediction intervals (PI). To obtain the total number of excess deaths for the entire time window, we subtracted the total number of expected (forecast) deaths from the total number of observed deaths. We obtained a 95% PI for the total by simulating the model 10,000 times, selecting the 97.5% and 2.5% quantiles, and subtracting the total number of observed deaths. We report in our tables the observed number of deaths divided by the expected number of deaths, as predicted by our models. We interpret these ratios as risk ratios for mortality, comparing pandemic time to non-pandemic time. We also estimated excess mortality for all specific occupations; for individual occupations, we defined excess mortality and risk ratios by comparing 2020 deaths to the arithmetic mean of 2018 and 2019 deaths.

We conducted all analyses in R, version 4.04.

Results

We estimate that from March 2020 through October 2020, there were 10,047 (95% PI: 9,229–10,879) excess deaths among Californians 18–65 years of age (Table 1). Relatively large numbers of excess deaths were recorded among workers in the facilities sector (1,681; 95% PI: 1,447–1,919) and the transportation/logistics sector (1,542; 95% PI: 1,350–1,738). Relative to pre-pandemic time, mortality increased during the pandemic by 39% among food/agriculture workers (risk ratio RR=1.39; 95% PI: 1.32–1.48), 28% among transportation/logistics workers (RR=1.28; 95% PI: 1.24–1.33), 27% among facilities workers (RR=1.27; 95% PI: 1.22–1.32), and 23% (RR=1.23; 95% PI: 1.18–1.28) among manufacturing workers.

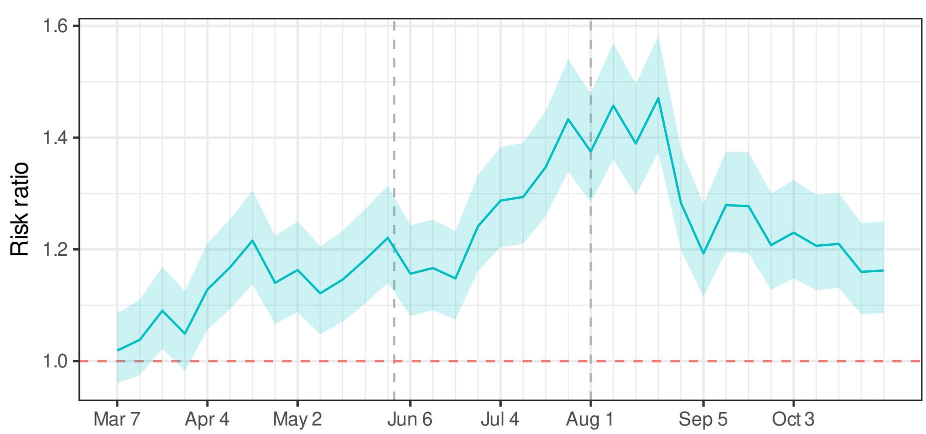
Table 1. Excess mortality among Californians 18–65 years of age, by occupational sector: March through October 2020.

	Excess deaths	Risk ratio[a]
Entire state	10,047 (9,229–10,879)	1.22 (1.20–1.24)
Facilities	1,681 (1,447–1,919)	1.27 (1.22–1.32)
Food or agriculture	1,050 (897–1,204)	1.39 (1.32–1.48)
Government or community	422 (324–520)	1.14 (1.11–1.18)
Health or emergency	585 (523–647)	1.19 (1.17–1.22)
Manufacturing	638 (530–749)	1.23 (1.18–1.28)
Retail	646 (517–778)	1.18 (1.14–1.23)
Transportation or logistics	1,542 (1,350–1,738)	1.28 (1.24–1.33)
Not essential	1,167 (910–1,428)	1.11 (1.08–1.14)
Unemployed or missing	1,969 (1,718–2,225)	1.23 (1.19–1.27)

[a] Risk ratios are defined as the observed number of deaths divided by the expected number of deaths. They are interpretable as the risk ratio for mortality, comparing pandemic time to non-pandemic time.

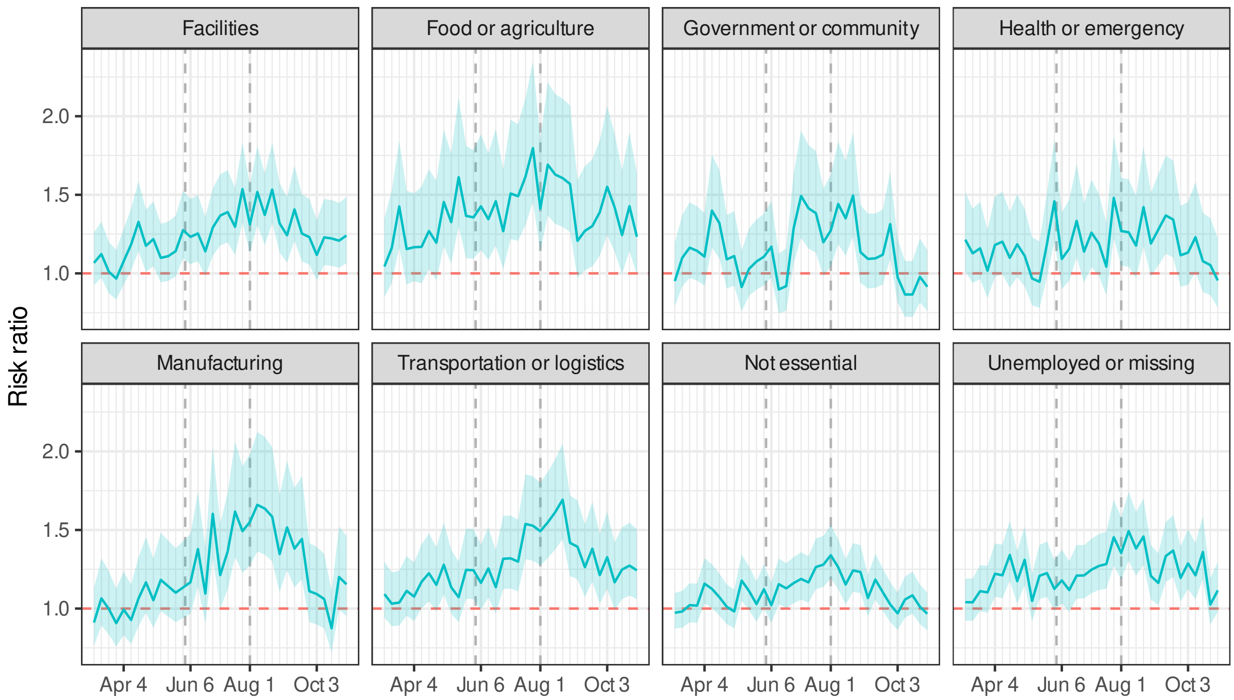
Relative increases in mortality varied over time (Fig 1) and by occupational sector (Fig 2). In March through May, there was a 14% increase in mortality among all working-age Californians (RR=1.14; 95% PI: 1.09–1.20) compared to a 31% increase among workers in the food/agriculture (RR=1.31; 95% PI: 1.17–1.49). In the months of June and July, the RR were particularly high in the food/agriculture (RR=1.61; 95% PI: 1.44–1.83), transportation/logistics (RR=1.52; 95% PI: 1.38–1.69), manufacturing (RR=1.52; 95% PI: 1.37–1.72), and facilities sectors (RR=1.44; 95% PI: 1.31–1.61).

Figure 1. Risk ratios for death, comparing pandemic time to non-pandemic time, among Californians 18–65 years of age, March through October 2020.



The dashed vertical lines mark boundaries between phases of California's major pandemic policies, lagged to acknowledge time from policy decisions to infection to death. The first phase corresponds to a period of sheltering in place, while the second phase corresponds to a period of reopening.

Figure 2. Risk ratios for death, comparing pandemic time to non-pandemic time, among Californians 18–65 years of age, by occupational sector, March through October 2020.



The dashed vertical lines mark boundaries between phases of California's major pandemic policies, lagged to acknowledge time from policy decisions to infection to death. The first phase corresponds to a period of sheltering in place, while the second phase corresponds to a period of reopening.

RR also varied by race/ethnicity (Table 2). Latino Californians experienced a 36% increase in mortality during the pandemic (RR=1.36; 95% PI: 1.29–1.44), with a 59% increase among Latino food/agriculture workers (RR=1.59; 95% PI: 1.47–1.75). Black Californians experienced a 28% increase in mortality (RR=1.28; 95% PI: 1.24–1.33), with a 36% increase for Black retail workers (RR=1.36; 95% PI: 1.21–1.55). Asian Californians experienced an 18% increase (RR=1.18; 95% PI: 1.14–1.23), with a 40% increase among Asian healthcare workers (RR=1.40; 95% PI: 1.33–1.49). Mortality among White working-age Californians increased by 6% (RR=1.06; 95% PI: 1.02–1.12) with a 16% increase among White food/agriculture workers (RR=1.16; 95% PI: 1.09–1.24).

Table 2. Risk ratios for mortality, comparing pandemic time to non-pandemic time, among California residents 18–65 years of age, by occupational sector and race/ethnicity, March through October 2020.

	All races	Asian	Black	Latino	White
All sectors	1.22 (1.20–1.24)	1.18 (1.14–1.23)	1.28 (1.24–1.33)	1.36 (1.29–1.44)	1.06 (1.02–1.12)
Food or agriculture	1.39 (1.32–1.48)	1.18 (1.05–1.33)	1.34 (1.19–1.54)	1.59 (1.47–1.75)	1.16 (1.09–1.24)
Transportation or logistics	1.28 (1.24–1.33)	1.26 (1.12–1.44)	1.35 (1.26–1.46)	1.40 (1.31–1.52)	1.10 (1.02–1.20)
Facilities	1.27 (1.22–1.32)	1.24 (1.08–1.46)	1.25 (1.17–1.34)	1.38 (1.27–1.51)	1.11 (1.04–1.20)
Unemployed or missing	1.23 (1.19–1.27)	1.08 (1.04–1.14)	1.31 (1.22–1.40)	1.31 (1.22–1.41)	1.09 (1.01–1.20)
Manufacturing	1.23 (1.18–1.28)	1.18 (1.06–1.33)	1.13 (1.01–1.30)	1.44 (1.34–1.57)	1.00 (0.92–1.10)
Health or emergency	1.19 (1.17–1.22)	1.40 (1.33–1.49)	1.27 (1.17–1.40)	1.32 (1.18–1.51)	1.02 (0.96–1.10)
Retail	1.18 (1.14–1.23)	1.10 (1.00–1.22)	1.36 (1.21–1.55)	1.40 (1.28–1.55)	1.08 (1.04–1.13)
Government or community	1.14 (1.11–1.18)	1.22 (1.07–1.41)	1.20 (1.09–1.33)	1.42 (1.32–1.53)	0.96 (0.89–1.04)
Not essential	1.11 (1.08–1.14)	1.14 (1.06–1.23)	1.23 (1.15–1.33)	1.29 (1.20–1.41)	1.00 (0.95–1.07)

Per occupation (Table 3), risk ratios for mortality comparing pandemic time to non-pandemic time were highest among cooks (RR=1.60), packaging and filling machine operators and tenders (RR=1.59), miscellaneous agricultural workers (RR=1.55), bakers (RR=1.50), and construction laborers (RR=1.49).

Table 3. Risk ratios for mortality, comparing pandemic time to non-pandemic time, among California residents 18–65 years of age, by occupation, March through October 2020.

Code	Description	Deaths[a]	Risk ratio
4020	Cooks	828	1.60
8800	Packaging and filling machine operators and tenders	172	1.59
6050	Miscellaneous agricultural workers	617	1.55
7800	Bakers	104	1.50
6260	Construction laborers	1,587	1.49
8965	Production workers, all other	452	1.46
8320	Sewing machine operators	127	1.44
5610	Shipping, receiving, and traffic clerks	146	1.44
4250	Grounds maintenance workers	712	1.40
5240	Customer service representatives	562	1.37
4000	Chefs and head cooks	532	1.35
1107	Computer occupations, all other	136	1.35
9600	Industrial truck and tractor operators	364	1.34
3500	Licensed practical and licensed vocational nurses	109	1.34
0410	Property, real estate, and community association managers	157	1.33
4230	Maids and housekeeping cleaners	378	1.33
3930	Security guards and gaming surveillance officers	707	1.32
9130	Driver/sales workers and truck drivers	1,962	1.32
9830	Military, rank not specified	111	1.32
9620	Laborers and freight, stock, and material movers, hand	2,550	1.31
5940	Office and administrative support workers, all other	123	1.30
7750	Miscellaneous assemblers and fabricators	354	1.29
2010	Social workers	217	1.28
4040	Bartenders	148	1.28
2540	Teacher assistants	183	1.28

[a] Number of deaths in pandemic time. The table is restricted to occupations with 100 or more pandemic-time deaths.

Discussion

Our analysis of deaths among Californians between the ages of 18 and 65 shows that the pandemic's effects on mortality have been greatest among essential workers, particularly those in the food/agriculture, transportation/logistics, facilities, and manufacturing sectors. Such workers experienced an increased risk of mortality of greater than 20% during the pandemic, with an increased risk of greater than 40% during the first two full months of the state's reopening. Excess mortality in high-risk occupational sectors was evident in analyses stratified by race/ethnicity, especially for Latino, Black, and Asian workers.

Our findings are consistent with a small but growing body of literature demonstrating occupational risks for SARS-CoV-2 infection. For example, a study of the UK Biobank cohort found that essential workers, particularly healthcare workers, had high risks for COVID-19 [10]. Similarly, numerous studies have documented SARS-CoV-2 infection among healthcare workers [11]. Our study, however, is unique in examining excess mortality and multiple occupational sectors. Though our work is in agreement with prior studies in finding pandemic-related risks among healthcare workers [11], it suggests that the risks are even higher in other sectors, such as food/agriculture and transportation/logistics.

This study is also among the first to examine deaths by both occupation and race/ethnicity. Occupational exposures have been postulated as an important contributor for disparities in excess mortality by race ethnicity, particularly because certain occupations require in-person work [4]. Though we tended to find the largest relative increases in mortality in each racial/ethnic group in the food/agriculture and transportation/logistics sectors, there was variation across race/ethnicity. For example, among Asians, the largest RR was in the health/emergency sector, even though the relative risk increases in that sector were relatively low among other racial/ethnic groups. Such differences may reflect cross-sector differences in demographics. There are, for example, a large number of Latinos who work in meat-processing facilities [12], consistent with data that show that Latinos make up a large proportion of COVID-19 cases in such settings [13]. Similarly, the large RR among Asians in the health/emergency sector could be due to the relatively large number of Filipino Americans in nursing professions [14]. During the pandemic in particular, such disproportionate representation may easily lead to cross-race variability in risk. A recent study found, for example, that Black workers are more likely to be employed in occupations that frequently require close proximity to others [15]. Inequalities in risk may be exacerbated by underlying structural inequities, such as immigration status or poverty [16].

Though non-occupational risk factors may be relevant, it is clear that eliminating COVID-19 will require addressing occupational risks. In-person essential workers are unique in that they are not protected by shelter-in-place policies. Indeed, our study shows that excess mortality rose sharply in the food/agriculture sector during the state's first shelter-in-place period, from late March through May; these increases were not seen among those working in non-essential sectors. Complementary policies are necessary to protect those who cannot work from home. These can and should include: free personal protective equipment, clearly defined and strongly enforced safety protocols, easily accessible testing, generous sick policies, and appropriate responses to workplace safety violations. As jurisdictions struggle with difficult decisions regarding vaccine distribution, our findings offer a clear point of clarity: vaccination programs prioritizing workers in sectors such as food/agriculture are likely to have disproportionately large benefits for reducing COVID-19 mortality.

We acknowledge limitations to the study, including misclassification of occupation in death certificates due to coarse categories or inaccurate reports. The decedent's primary occupation is typically reported by the next of kin who may not be able to precisely describe the work. The primary occupation, which is reported on the death certificate, may not match the most recent occupation, which is more likely to drive occupational risk. These limitations would in general attenuate apparent differences across occupational sectors but are unlikely to account for our primary results.

Our study places a powerful lens on the unjust impact of the COVID-19 pandemic on mortality of working age adults in different occupations. Our analysis is among the first to identify non-healthcare in-person essential work, such as food and agriculture, as a predictor of pandemic-related mortality. Essential workers—especially those in the food/agriculture, transportation/logistics, facilities, and manufacturing sectors—face increased risks for pandemic-related mortality. Shutdown policies by definition do not protect essential workers and must be complemented with workplace modifications and prioritized vaccine distribution. If indeed these workers are essential, we must be swift and decisive in enacting measures that will treat their lives as such.

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Livestock plants and COVID-19 transmission

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Policy responses to the COVID-19 outbreak must strike a balance between maintaining essential supply chains and limiting the spread of the virus. Our results indicate a strong positive relationship between livestock-processing plants and local community transmission of COVID-19, suggesting that these plants may act as transmission vectors into the surrounding population and accelerate the spread of the virus beyond what would be predicted solely by population risk characteristics. We estimate the total excess COVID-19 cases and deaths associated with proximity to livestock plants to be 236,000 to 310,000 (6 to 8% of all US cases) and 4,300 to 5,200 (3 to 4% of all US deaths), respectively, as of July 21, 2020, with the vast majority likely related to community spread outside these plants. The association is found primarily among large processing facilities and large meatpacking companies. In addition, we find evidence that plant closures attenuated county-wide cases and that plants that received permission from the US Department of Agriculture to increase their production-line speeds saw more county-wide cases. Ensuring both public health and robust essential supply chains may require an increase in meatpacking oversight and potentially a shift toward more decentralized, smaller-scale meat production.

COVID-19 | supply chains | livestock | agriculture | public health

Among the many challenges posed by the COVID-19 outbreak, maintaining essential supply chains while mitigating community spread of the virus is vital to society. Using county-level data as of July 21, 2020, we test the relationship between one such type of essential activity, livestock processing, and the local incidence of COVID-19 cases. We find that the presence of a slaughtering plant in a county is associated with four to six additional COVID-19 cases per thousand, or a 51 to 75% increase from the baseline rate. We also find an increase in the death rate by 0.07 to 0.1 deaths per thousand people, or 37 to 50% over the baseline rate. Our estimates imply that excess COVID-19 infections and deaths related to livestock plants are 236,000 to 310,000 (6 to 8% of all US cases) and 4,300 to 5,200 (3 to 4% of all US deaths), respectively, with the vast majority occurring among people *not* working at livestock plants.

We further find the temporary closure of high-risk plants to be followed by lower rates of COVID-19 case growth. We also find that smaller, decentralized facilities do not appear to contribute to transmission and that plants that received permission from the US Department of Agriculture (USDA) to increase their production-line speeds saw more county-wide cases. Our associations hold after controlling for population risk factors and other potential confounders, such as testing rates. Although lacking a natural experiment to cement causality, we employ a combination of empirical tools—including an event study, instrumental variables (IVs), and matching—to support our findings.

The centrality of livestock processing to local economies and national food supplies implies that mitigating disease spread through this channel may take an economic toll. Understanding the public health risk posed by livestock processing is essential for assessing potential impacts of policy action. However, generating case data attributable to livestock plants is challenging: Contact tracing in the United States is decentralized and sporadic, and there may be incentives for companies and government bodies to obscure case reporting (1–5). Our study represents an attempt to address this gap in knowledge.

Heterogeneity in COVID-19 Patterns

The disease burden of COVID-19 is not uniformly distributed across the global population. Certain conditions appear to influence the degree to which people spread the virus. Some contexts and social behaviors are believed to lead to superspreading events that disproportionately affect local populations (6, 7). Previous studies have explored links between the incidence of COVID-19 cases and a range of demographic and environmental factors, such as age, occupation, income, race, intergenerational mixing, temperature, and humidity (8–13). Social, commercial, and industrial activities are also believed to affect transmission, for which reason countries worldwide have implemented a range of economic and social-distancing measures (8, 14–20). In the United States, some industries are exempted from shelter-in-place orders and have remained operational due to their necessity to satisfy basic societal needs (21). We investigate the relationship between transmission and one such activity, livestock processing.

COVID-19 and Livestock Plants

The livestock- and poultry-processing industry is an essential component of the global food supply chain. In the United States, it is a large industry, employing 500,000 people. It is also highly concentrated: The largest four companies in beef, pork, and poultry processing capture 55 to 85% of their respective markets (22–27). This degree of concentration stands in contrast to the European Union (EU), for example, where the top 15 meat companies represent 28% of EU meat production (28).

Significance

The COVID-19 pandemic is a public health and economic crisis in which policymakers face tradeoffs between maintaining essential economic activities and mitigating disease spread. Our study suggests that, among essential industries, livestock processing poses a particular public health risk extending far beyond meatpacking companies and their employees. We estimate livestock plants to be associated with 236,000 to 310,000 COVID-19 cases (6 to 8% of total) and 4,300 to 5,200 deaths (3 to 4% of total) as of July 21. We also illustrate potential contributions of plant size, industrial concentration, plant shutdowns, and policy actions to this phenomenon. These results motivate investigation into supply chains, operating procedures, and labor relations within the meatpacking industry.

Author contributions: C.A.T., C.B., and D.A. designed research, performed research, analyzed data, and wrote the paper.

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Over the decades, the livestock- and poultry-processing industry in the United States has consolidated its operations into fewer, larger plants, in which meat production per plant has increased threefold since 1976 (29, 30). Today, 12 plants produce over 50% of the country's beef, and 12 others, similarly, produce over 50% of the country's pork (30, 31). Early in the COVID-19 pandemic, livestock-processing plants worldwide experienced spikes in infections, facing shutdowns that disrupted meat and dairy supplies (32–35). In the United States, reports of COVID-19 spreading within the livestock-processing industry led to increased attention and updated safety guidance by the Centers for Disease Control and Prevention (CDC) (22). Several plants were forced to shut down until, among other factors, a federal executive order invoked the status of livestock processing as "critical infrastructure" for national security and mandated that these plants remain open (36, 37).

Work routines in livestock processing have several characteristics that make plants susceptible to local outbreaks of respiratory viruses. The CDC includes the following among potential risk factors: long work shifts in close proximity to coworkers, difficulty in maintaining proper face covering due to physical demands, and shared transportation among workers (22). Previous research has proposed occupational exposure to livestock animals as a driver of viral spread, although an experimental study did not find pigs or chickens to be susceptible to the SARS-CoV-2 virus associated with COVID-19 (38–41). Increases in production-line speeds due to technological enhancements as well as policy changes have also been hypothesized to exacerbate COVID-19 transmission (5, 42). Among those we investigate are USDA waivers on poultry-production line-speed limits for plants with strong commercial production practices and microbial control (43).*

The indoor climate of livestock facilities may increase transmission risk. To preserve meat after slaughter, processing areas are maintained at 0 to 12 °C (44), and such low temperatures have been linked to increased COVID-19 risk (45, 46). Though these rooms are kept at 90 to 95% relative humidity to prevent meat from drying and losing weight, the low absolute humidity at near-freezing temperatures may encourage the transmission of airborne viruses such as influenza (47–49). Moreover, studies have suggested that industrial climate control systems used to cool and ventilate meat processing facilities may further the spread of pathogenic bioaerosols, a proposed COVID-19 transmission route (46, 50–53).

Workers' socioeconomic status and labor practices may also contribute to infection and transmission. Among front-line meat-processing workers in the United States, 45% are categorized as low income, 80% are people of color, and 52% are immigrants, many of whom are undocumented and lack ready access to healthcare and other worker protections that could facilitate COVID-19 prevention and treatment (54–56). In addition, employees at these facilities may face incentives to continue working even while sick through company policies on medical leave and attendance bonuses (5, 22, 57). In addition, through consolidation over the decades, the meatpacking industry has potentially increased its monopsonistic power over labor markets, which has been linked to greater work hazards (58–60).

Results

We find a strong relationship between proximity of livestock plants and the incidence of COVID-19 over time. Fig. 1 plots average COVID-19 case and death rates over time by whether there is a large livestock facility in a given county relative to rates in counties at varying distances from a plant. In both cases, we see an increasing divergence in outcomes beginning in early April based on livestock-plant proximity.

Fig. 1 does not account for county-level differences in terms of density and demographics. In Table 1, we estimate the relationship between livestock plants and COVID-19 incidence as of July 21, 2020, using regression models that control for potential confounding variables, including county-level measures of income; population density and its square; the timing of the first case; the proportions of elderly people, uninsured people, front-line workers, and people using public transportation; racial and ethnic characteristics; average household size; local freight traffic; and populations of nursing homes and prisons. We find that livestock plants are associated with an increase in COVID-19 cases by approximately four per thousand people, representing a 51% increase over the July 21 baseline rate of eight per thousand. Likewise, death rates increase by 0.07 per thousand, or 37% over the county baseline of 0.2 deaths per thousand. The results are robust both nationally and when only considering variation within states after including state fixed effects. We also use an alternate specification with a binary measure of whether a county has one or more livestock plants. Such counties are associated with six additional cases per thousand, or a 75% increase over the baseline, as well as 0.1 additional deaths per thousand, or 50% over the baseline county death rate.† In addition, COVID-19 appears to arrive earlier in counties with livestock plants (*SI Appendix*, Table S2).

Heterogeneity by Facility Type, Size, Operations, and Company. We now present potential characteristics of livestock facilities that might contribute to these observed relationships with the COVID-19 case and death rate.

Facility type. We first looked at the relationship between reported cases and the type of animal slaughtered or processed. We found that beef, pork, and poultry plants each show a significant relationship with COVID-19 cases and deaths, with pork plants showing the greatest measured magnitude of the three in cases and beef plants showing the greatest magnitude in deaths (*SI Appendix*, Table S3). As seen in the map in Fig. 2, pork and beef plants are well distributed throughout the United States, and, although, poultry plants are relatively concentrated in the southeastern United States, they are found across 10 states. Overall, the wide geographic distribution of facilities by type mitigates concerns of this being a regional phenomenon.

Facility size. We next investigated whether there are differential relationships with COVID-19 transmission based on the size of processing facilities. Livestock facility data were gathered from the USDA's Food Safety and Inspection Service (FSIS). *SI Appendix*, Table S4 categorizes beef, pork, and poultry plants by order of magnitude based on the pounds per month processed: large (category 5; over 10 million), medium (category 4; over 1 million), and small (category 3; over 100,000 and under 1 million). Each size category was sufficiently represented, with 349 small plants, 126 medium plants, and 225 large plants. Very small plants (categories 1 and 2), which are often niche providers, were excluded.‡

*The CEOs of Wayne Farms and Tyson Foods—both granted waivers in April 2020—are, respectively, chairman of the National Chicken Council (the body that initially lobbied for the line speed waivers) and a public advocate for the poultry industry, buying full-page newspaper ads in April stating that the food supply chain was "broken."

†In line with the literature, we find COVID-19 incidence to be strongly associated with population density, average household size, the timing of the first confirmed case, and the proportion of a county's population who are public-transit commuters, elderly, Black, Hispanic, in a nursing home, uninsured, or institutionalized (*SI Appendix*, Table S1).

‡In our main analyses, we included category 4 and 5 pork and beef facilities and category 5 poultry facilities (which comprise 57% of total poultry plants); see *Materials and Methods* for a full discussion.

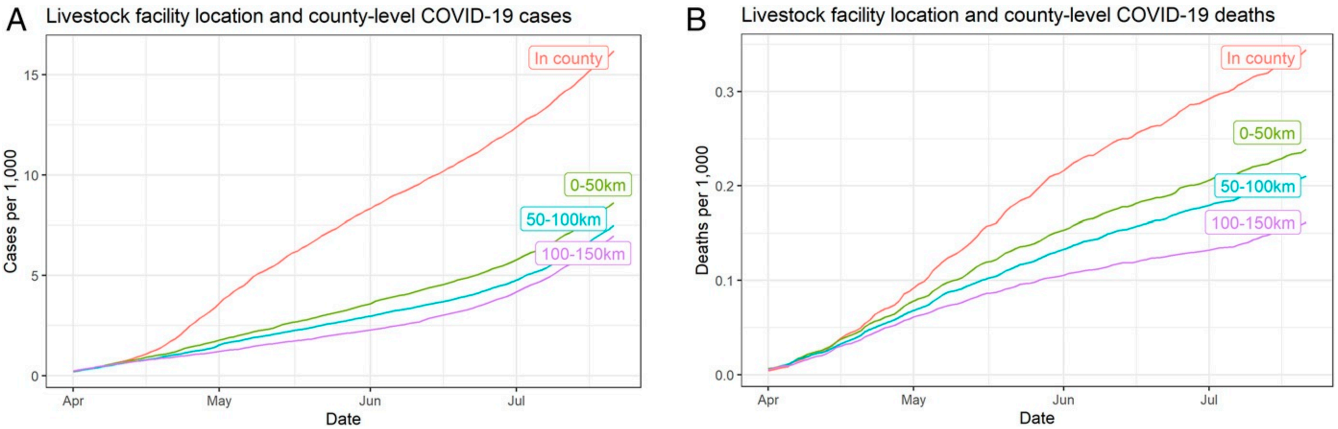

Fig. 1. Mean county-level COVID-19 cases per thousand (*A*) and deaths per thousand (*B*) over time based on proximity to a livestock facility. The band "0–50 km" excludes the county itself. Counties are categorized into nonoverlapping, single categories based on the nearest facility (e.g., if a county contains a livestock facility and is within 50 km of another facility outside the county, the county is coded "In county" and not "0–50 km"). A visualization map is included in *SI Appendix*, Fig. S1.

We found the relationship between livestock plants and COVID-19 transmission to be most pronounced among the largest plants, whose presence in a county is associated with a 35% higher COVID-19 case rate relative to the average coefficient for livestock plants shown in Table 1. Small and medium-sized plants were generally not found to have significant relationships with local COVID-19 transmission, suggesting that the scale of production is an important variable for industry leaders and policymakers to consider.

Production line speeds. We next examined whether there is a relationship between local COVID-19 transmission and plant-operating procedures. We collected data on whether a poultry plant had been granted a waiver from the USDA permitting production-line processing speeds of 175 birds per minute, up from the statutory limit of 140. Waivers were first issued to 20 poultry plants in 2012 as part of a pilot study to test self-monitoring of safety. It was then expanded in September 2018 to allow all poultry plants the opportunity to apply for these waivers. A faster production line can result in both workers locating in greater proximity to one another and increased difficulty in maintaining personal protective equipment and thus could contribute to conditions that increase the likelihood of viral transmission.

Of the 120 poultry plants in our sample, 48 plants currently have waivers, 16 of which were issued in 2020.[§] An analysis of the relationship between line speed waivers and local COVID-19 incidence suggests, though with less precise estimates, that waivers predict increases in county-level case rates double those in counties with nonwaiver poultry plants (*SI Appendix*, Table S5). Among plants issued a waiver in 2020, the relationship is even greater in magnitude. This finding suggests a potential pathway between a livestock plant's operating procedures and COVID-19 transmission.

Facility operator. We next looked at differential relationships with COVID-19 by company. The relationship between local COVID-19 incidence and medium and large plants (FSIS categories 4 or 5) owned or operated by some of the largest US processors (National Beef, JBS, Tyson, Cargill, and Smithfield) and their subsidiaries is presented in *SI Appendix*, Table S6. These magnitudes can be visualized in Fig. 3: The strongest relationship is found with National Beef, whose indicated relationship with COVID-19 case rates is approximately five times greater in magnitude than that of other livestock facilities. However, all of the large companies appear to have larger coefficients than the baseline. Aside from Smithfield, the relationship with deaths is positive, albeit less significant, which may be due to small sample size.[¶]

Behavioral change. If livestock facilities are driving higher COVID-19 incidence, and if livestock processing is an essential industry, we would expect people in livestock-plant counties to work more compared to those in nonlivestock counties in response to COVID-related lockdowns. To this end, we employed county-level mobility data made available by Google for COVID-19 researchers. We constructed a baseline measure of average time-use change before and after March 13, 2020, the date the United States declared a national disaster in relation to COVID-19 and shortly after the World Health Organization declared COVID-19 a pandemic.

We then examined how the presence of livestock plants varied with time spent working and engaging in shopping and recreation. We controlled for the same demographic and location-based covariates as in other models. We found that the presence of livestock plants is strongly associated with more time spent at work (*SI Appendix*, Table S7). This association is relative to the baseline behavior change across all other counties, indicating that people in livestock-plant counties are working more (or cutting back on work less) than people in other counties. Meanwhile, there is a lesser and imprecise relationship with retail and recreation activities, which may contribute to viral spread. This supports the notion that livestock plants, rather than unrelated changes in behavior in these same counties, are the more likely vehicle of COVID-19 transmission.[‖]

Plant shutdowns. Many livestock plants were temporarily shut down to halt the spread of COVID-19. In such cases, we would expect the dynamics of caseloads and deaths over time to vary negatively with the timing of shutdown, after a lag. Were confounders instead driving our results, they would have to follow

§Among counties with poultry plants, those with and without waivers appear similar in their average characteristics, reducing waiver-selection concerns. The exception is that waiver counties have lower proportions of Black residents and prison populations, factors associated with increased COVID-19 risk.

¶In our collected sample, the number of facilities per company varies: National Beef has only seven plants in seven counties, whereas Tyson Foods has 80 plants across 69 counties. The other companies fall somewhere in between.

‖It is possible that additional time spent working, and thus out of the house, may explain some of the additional time spent on retail activities (e.g., gas stations or workday meals).

Table 1. Livestock facilities and county-level COVID-19 incidence

	COVID-19 incidence per 1,000 as of July 21, 2020					
	Case rate			Death rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Livestock facility	4.49***	4.07***	5.98***	0.07***	0.07***	0.10***
	(0.88)	(0.80)	(1.14)	(0.02)	(0.02)	(0.02)
Plant count	Level	Level	Binary	Level	Level	Binary
Controls	X	X	X	X	X	X
State FE		X	X		X	X
Observations	3,032	3,032	3,032	3,032	3,032	3,032
R^2	0.36	0.45	0.46	0.27	0.42	0.42

Regression model with cross-sectional county data. Dependent variable is COVID-19 cases (models 1 to 3) and deaths (models 4 to 6) per thousand. Livestock facility level is the sum of beef, pork, and poultry plants in the county. Livestock facility binary denotes a binary variable representing whether a county has at least one livestock plant. Controls include income per capita (log), density (population per built-up land area) and density squared, the number of freight miles traveled, and timing of first case (index of Julian day of first confirmed case), as well as proportions of the county population over the age of 70, Black, Hispanic, public-transit commuters, uninsured, frontline workers, or in nursing homes or prisons. State-level fixed effects (FE) are included in models 2, 3, 5, and 6. SEs are clustered at the state level.

$^{***}P < 0.01$.

the timing of the plant shutdowns as well. This helps argue against purely static confounders, such as highway connectedness or fraction of the population that is Hispanic.

Using a dataset tracking whether and when livestock plants closed, Fig. 4 presents an event study comparing the change in weekly COVID-19 case rates before and after closure, averaged across counties with plants that closed and counties with plants with no evidence of closure. Among livestock plants in our sample, we have the dates of closures that occurred in 26 counties, or 10% of counties with plants. The mean closure time was 9 d. Some closed for a day or two for cleaning and disinfection, while others closed for longer periods while revising their operating procedures and monitoring staff. On the other hand, many plants remained open due to a perceived lack of risk, while others remained open despite significant local outbreaks.

In this event study, we examined case growth (weekly log difference), following the structure of a previous analysis (61), as well as change in case rates. In addition, we performed prepolicy matching across the two groups based on percent case growth in the 2 wk prior to shutdown. In doing so, we selected the top quartile of growth rates among the 233 counties with livestock plants that did not have a plant shutdown. We took this step to maximize comparability between the two groups, as we observed that preclosure growth in cases was, on the whole, greater in plants that closed (*SI Appendix*, Fig. S2).

Coefficients are plotted from a panel regression, where counties (categorized as either having or not having a plant closure) are interacted with the weekly event index, both in terms of percent growth in cases (Fig. 4 *A* and *C*) and the change in case rates per 1,000 (Fig. 4 *B* and *D*). This model controls for state-level social distancing and stay-at-home policy and includes a fixed effect for each county, thereby isolating within-county variation in timing (among counties with plant closures).

Fig. 4 shows that plant closures occurred in counties experiencing high growth in COVID-19 cases, as might be expected. Within 1 wk of closure, however, the growth rate in shutdown counties reverted to the prepolicy growth rate from a higher peak, compared to nonshutdown counties in the same time. By week 2, growth rates between the two categories, highly divergent in week 1, were roughly equal. By weeks 3 to 4, average growth rates in shutdown counties were, in fact, lower than even counties without plants. This lag structure for cases aligns with the fact that COVID-19 incubation periods may last for up to 14 d (62).

The lower sustained COVID-19 growth rate postclosure suggests that plant closures have some relationship with COVID-19 transmission, which, in turn, suggests some relationship between plant-level activity and community disease spread within the county. Given that the average closing period was only 9 d, it is unclear whether the plant closures themselves reduced COVID-19 transmission rates, or whether closures resulted in plants taking more COVID-19 precautions (e.g., implementing enhanced safety protocols). It is also true that locales initially experiencing growth spikes will likely revert to average growth rates over time. However, the speed with which growth rates rose and fell in shutdown counties suggests that some closure-related mechanism is likely at play. And while shutdown counties have higher cumulative COVID-19 caseloads on average, this is likely because closures occurred too late to suppress community spread outside of these plants.

Robustness.

COVID-19 testing. Next, we address concerns that these results primarily reflect differences in testing. Places with more testing tend to have more confirmed COVID-19 cases than places with less testing (mechanically). There does not appear to be a national database on county-level testing, so we compiled data from 31 states that have livestock facilities and testing data at the county level. Table 2 shows that, while testing is positively associated with COVID-19 incidence, the relationship to livestock facilities remains large and significant. In a second specification, we added the positivity rate (total cases divided by total tests) as a further control. The magnitude of the livestock coefficients are of a similar magnitude to those in the baseline model in Table 1. However, these estimates are not directly comparable because of the smaller sample size of counties with testing data (1,773 counties across the 31 states).

Manufacturing activity. It is possible that a certain type of work similar to livestock processing—but not livestock processing itself—is driving the spread of COVID-19. To test this, we controlled for the county-level number of manufacturing establishments and share of income from manufacturing. We found that the relationship between livestock plants and COVID-19 incidence remained largely stable, meaning that it is not explained by a correlation with manufacturing (*SI Appendix*, Table S8). While there is no obvious relationship with number of manufacturing establishments, the coefficient for manufacturing share of income is positive and statistically significant, implying that

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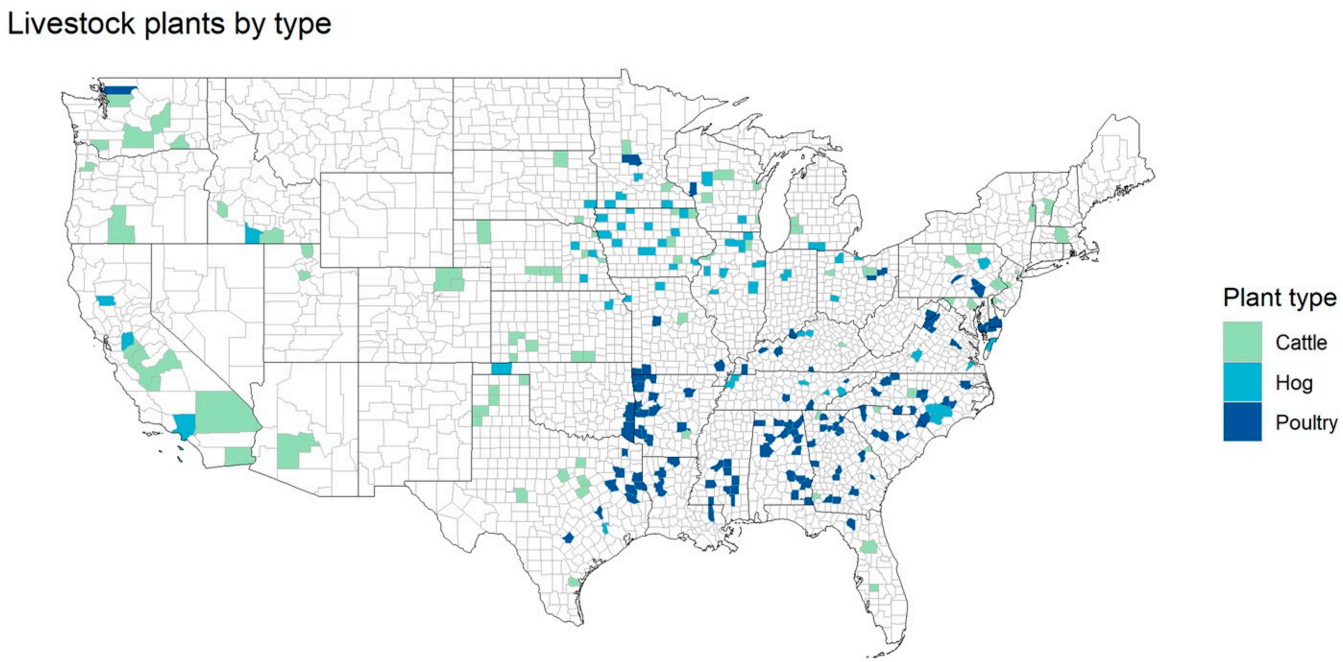

Fig. 2. Shaded counties contain at least one beef or pork facility categorized by USDA FSIS as processing more than 1 million pounds per month (categories 4 and 5) or at least one poultry facility categorized as processing more than 10 million pounds per month (category 5).

manufacturing may be associated with higher COVID-19 incidence. Such a relationship is plausible given that, like livestock processing, employees in the manufacturing sector may work in close proximity and that many manufacturing activities are considered essential to supply chains.

Dropping counties distant from livestock plants. Another potential concern is that counties very far from livestock plants have lower population densities and different demographic makeups than counties nearer these plants. Correspondingly, there is a risk that incorporating these counties into our analysis may introduce bias into our livestock-plant estimates. An analysis omitting counties more than 100 km from a county with a livestock plant showed a relationship with livestock facilities greater in magnitude than the base specification, indicating that our findings are robust to this risk and, perhaps, somewhat conservative (*SI Appendix*, Table S9).

Dependent-variable transformations. To address concerns about a skewed outcome variable, we employed the natural log and inverse hyperbolic sine of the dependent variable and found a consistently positive, but smaller-magnitude, relationship between livestock plants and increased COVID-19 case and death rates (*SI Appendix*, Table S10).

Alternative Statistical Approaches to Confounding. Above, we have shown the robustness of multivariate regression results to various confounders—demographic, geographic, and behavioral—and sample-selection criteria. Additionally, we have shown that the dynamics over time of COVID-19 cases and deaths vary with the timing of livestock-plant shutdowns.

Here, we present results of additional statistical methods used to explore the relationship between livestock plants and COVID-19 cases and deaths in the cross-section. The methods we used to help address potential bias and endogeneity concerns are IV analysis, propensity-score matching, and nearest-neighbor matching. We note that the 259 counties in our sample with livestock plants differ in important ways from those without plants. We constructed a balance table comparing counties with and without livestock plants (*SI Appendix*, Table S11). Counties with plants have higher population density, a lower proportion of elderly people, higher proportions of Black and Hispanic people, and larger household sizes. Income levels, by contrast, are similar. Each particular statistical method adjusts for these baseline differences in different ways. To preview, we find the observed relationship with COVID-19 incidence to be robust to all three approaches.

Instrumental variables. First, we employed an IV approach using historical livestock agricultural production data. The selection of this instrument was motivated by meat processors' need to minimize costs of transporting livestock supply when selecting the location of plants. In the first stage, we regressed the current number of livestock plants in each county on the county's livestock-production value in 1959 in terms of animals sold, as derived from the USDA census. Note that this only includes agricultural operations, and not livestock processing. We believe that this is a strong instrument, given that most of the interstate highway system was constructed during the 1960s, most currently operating livestock processing plants were built in the 1970s or later, and livestock agricultural operations in 1959 appear unlikely to affect current public health outcomes.

In the second stage, we regressed COVID-19 incidence on this predicted value of livestock plants as well as the other covariates in the primary specification. The first stage in the IV analysis, presented in *SI Appendix*, Table S12, shows that the instrument is highly relevant with the F-statistic far above Stock and Yogo's (63) 10% maximal bias threshold. The overall IV results in Table 3 show the relationship between livestock facilities and COVID-19 case and death rates to be even stronger for each outcome, except the within-state death rate, which is of comparable magnitude but less precisely estimated. We note that the IV approach restricts identifying variation to that attributable to livestock agriculture proximity, thereby reducing statistical power.

Propensity-score and nearest-neighbor matching. For both propensity-score matching and nearest-neighbor matching, we constructed comparable subsamples of our dataset with and without livestock facilities to estimate an effect of having these

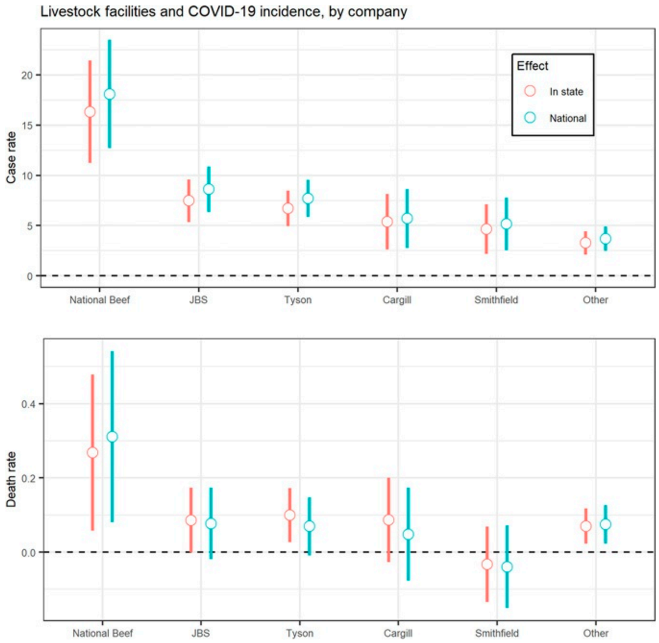

Fig. 3. Relationship between COVID-19 cases and livestock plants owned or operated by large meatpacking companies. Coefficients are firm fixed-effect coefficients plotted from *SI Appendix*, Table S6. Error bars represent 95% CIs.

livestock facilities among otherwise similar counties on COVID-19 cases and deaths.

For propensity-score matching, we first predicted the probability that a county has at least one livestock facility (binary value) using a binomial regression that includes all of the covariates from our primary model specification in Table 1, as well as their quadratic terms to increase model flexibility. We then confirmed that observations were relatively balanced across covariates within each propensity-score quartile (*SI Appendix*, Table S13. This suggests that the propensity score is, indeed, balancing the multidimensional covariates. In a second step, we used this predicted probability (i.e., the propensity score) as a control in a regression of COVID-19 incidence on livestock plants. The idea is that the propensity score helps account for bias in the location of livestock plants.

For nearest-neighbor matching, we used the *MatchIt* package in R to restrict the sample to similar treated and control groups. The matching occurred by using a nearest-neighbor algorithm based on predicting the livestock binary variable with the covariates in our primary specification. To ensure an adequate sample size, we allowed the algorithm to match two nonplant counties to every one county with a livestock plant. We found the resulting 774 county subsample to be well balanced (*SI Appendix*, Table S14).[**] *SI Appendix*, Table S15 consolidates the results and includes outputs from Table 1 for reference. In this analysis, coefficients for both case and death rates remain of a similar magnitude and level of significance.

Community spread beyond livestock plants. COVID-19 transmission likely extends beyond the county containing the livestock plant. *SI Appendix*, Fig. S3 expands our main analysis to include neighboring counties grouped by distance band, as charted in Fig. 1 and visualized in the map in *SI Appendix*, Fig. S1. We found evidence of a relationship between livestock plants and increased COVID-19 case rates up to 150 km away from a plant, further supporting the notion of community spread beyond the immediate work context.[††]

To validate and contextualize our findings, we first estimated the total excess cases and deaths related to livestock plants implied by our results. For one set of estimates, we multiplied the plant-level coefficient for excess cases and deaths related to livestock plants by the total number of plants and the average population per plant to arrive at a national total. A second approach used a binary measure for whether a county has one or more livestock plants and multiplied this coefficient by the county-level mean population and number of counties with livestock plants. The estimates resulting from this exercise were, respectively, 236,000 to 310,000 cases and 4,300 to 5,200 deaths. A summary of this calculation is shown in *SI Appendix*, Table S19.

Next, we estimated the share of cases among livestock employees relative to total excess cases in an attempt to determine the share of excess cases that may be occurring outside the livestock plants. We used the CDC's state-level aggregate count of livestock workers testing positive for COVID-19 as of May 31 across 26 states (64). Comparing this to state-level case data as of May 31, we found that livestock workers represented 2.7% of cases in these states. Using this ratio to estimate the total number of infected livestock workers among all of the cases observed in these states on July 21, we arrived at an estimate of 35,635 infected workers, ∼7% of the industry's entire employee base. Using our calculation of 236,000 to 310,000 cases nationwide due to livestock plants, we estimated that livestock workers represent 12 to 15% of these excess total cases. In other words, for every worker infected at a livestock plant, between seven and eight local nonworkers were ultimately infected by the end of the sample period, underscoring the high potential for community spread.

Discussion

Angrist and Krueger (65) noted that "one should always be wary of drawing causal inferences from observational data." We know of no random-assignment design that could address our research question and thereby yield the most reliable path to causal inference. The best we can do here is provide an unusually broad array of observational evidence. This includes (but is not limited to) ruling out the most obvious confounders, a cross-sectional IV, and the event-study analysis leveraging shutdown timing. A still more compelling natural experiment would leverage explicit and exogenous variation that drives livestock-plant shutdowns, i.e., an IV for the shutdowns or their timing. Unfortunately, we know of no such identifying variation.

Readers may disagree on whether our array of analyses has isolated a causal effect. Given this, and in order to be conservative, we avoided causal language throughout our text so as not to overstate the "hardness" of our method (66). This avoidance and caution stands in contrast to other recent, impactful work on COVID-19.

Still, we believe that our array of analyses constitutes the best feasible approach to shed light on the role of livestock-processing plants in the US COVID-19 pandemic. For a question of this importance, we believe there is no "harder" method available (66). As policymakers and industry leaders seek to preserve vital food-supply chains while mitigating the pandemic's spread, evidence on the potential scope of the issue is particularly valuable, as well as assessment of the relationship between temporary plant shutdowns and subsequent COVID-19 growth dynamics.

[**] A balance table for the entire sample is shown in *SI Appendix*, Table S11.

[††] We present summary statistics by distance band in *SI Appendix*, Tables S16–S18. The average number of counties in each band increases with distance. There is a clear positive relationship between COVID-19 cases and deaths in relation to livestock facilities, and the county-level mean case rate varies directly with a county's proximity to a neighboring county with a livestock facility.

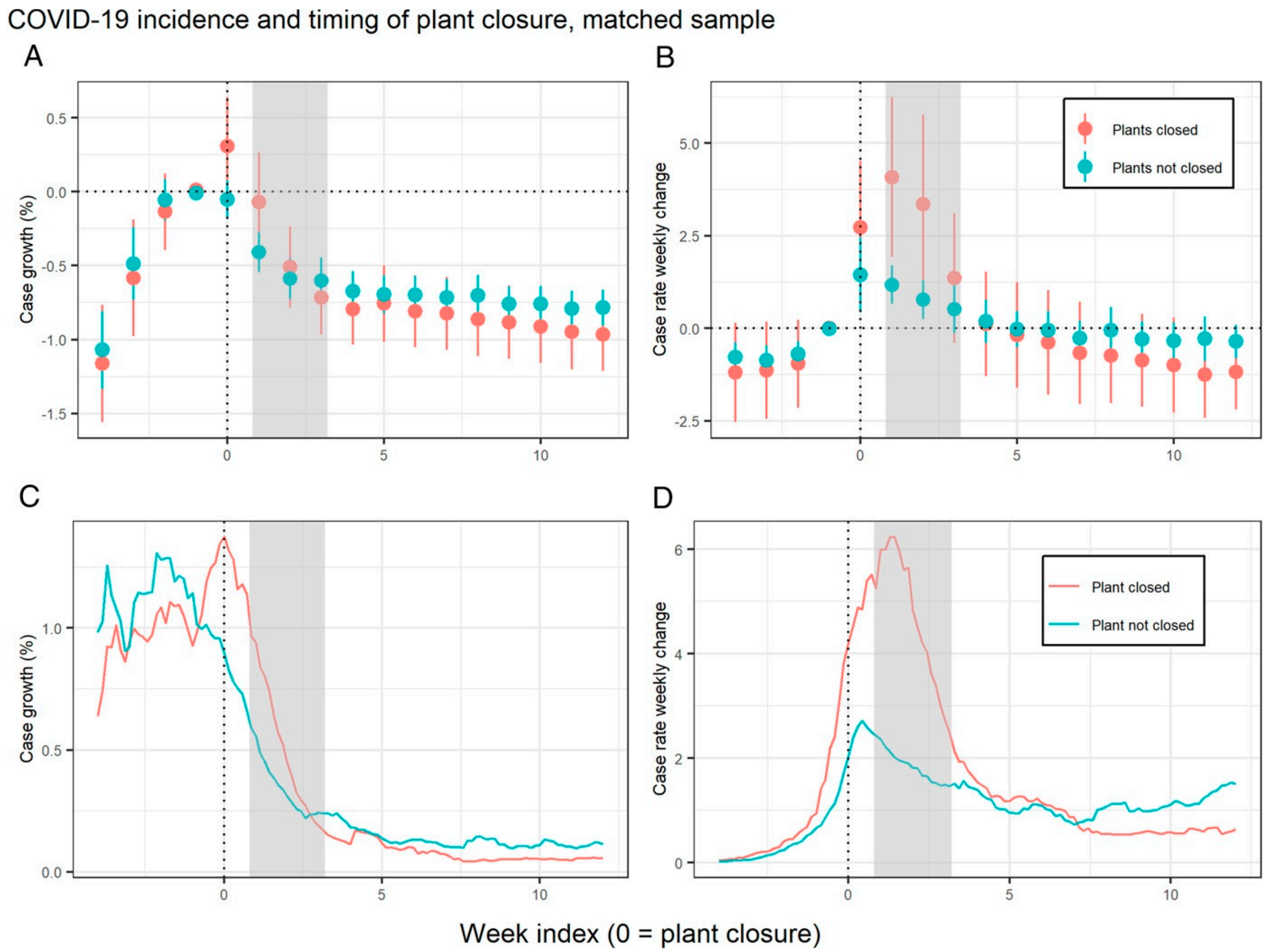

Fig. 4. Graphs match COVID-19 pretrends of control group (green lines) to counties with plant shutdowns (red lines) based on percent growth in cases (weekly log difference) in the 2 wk prior to shutdown. Selected counties are in the top quartile of growth rates among the 233 counties with livestock plants that did not have a plant shutdown. For nonshutdown counties, week 0 is assigned to the mean shutdown date, April 22, 2020. *A* and *B* plot coefficients from a panel regression, where counties are interacted with the weekly event index in terms of percent growth in cases (*A*) and change in case rates per 1,000 (*B*). Estimates are relative to the baseline trend across all counties. One week prior (week −1) is omitted as the reference level. Models control for stay-at-home orders at the state level and include a fixed effect for each county. Error bars reflect a 95% CI. *C* and *D* are daily line charts of the mean values of each group in terms of percent case growth and change in case rate, respectively. Gray shaded bars reflect the estimated period when the effect of closing a plant would have been reflected in cases (1 to 3 wk after), given that incubation periods may last up to 14 d) (62).

Although our estimate that 6 to 8% of COVID-19 cases are associated with livestock plants may appear high, it is important to recall that high levels of geographic heterogeneity in COVID-19 incidence can be explained by some combination of individual behavior, government policy, social-distancing compliance, and economic activity: The United States, for example, has 4% of the world's population, but approximately a quarter of all cases and deaths as of July 2020. When narrowing the geographic focus, we can imagine the distribution of COVID-19 incidence to be similarly clustered, if not even lumpier.

Kansas provides a telling example of the outsized role of livestock facilities: As of July 20, a total of 3,200 of 23,300 state cases (14%) were directly linked to meatpacking (67). For context, there are 17,200 employees in the animal-slaughtering industry in Kansas (68), or 0.6% of the state's population, suggesting that livestock plants had a relationship of a magnitude closer in scale to our own estimates (Kansas' estimate is 23× their labor footprint). Although the figure we are estimating in our study (6 to 8% of all US cases out of a national livestock workforce of 0.15%, or a multiplier of 40 to 53×) is larger, we believe that this finding is plausible, considering follow-on community spread; Kansas' official tally, though evidently aided by some degree of contract tracing, was reportedly hampered by lags in hiring staff and legislative actions that have inhibited tracing efforts (69). That is, the figure we have calculated could, in fact, be more complete than the Kansas figure in capturing the spread resulting from livestock plants.

Our analysis of individual meatpacking companies may present an opportunity to explore how differences in corporate structure and operating practices may account for their differential public health outcomes. In particular, the evidence that shutting down plants temporarily may be related to decreases in COVID-19 case growth presents a potentially powerful transmission mitigant. In addition, the positive relationship between COVID-19 transmission and production-line speed waivers issued to poultry plants, particularly those during the 2020 pandemic, is notable, given that these waivers are intended for plants with safe commercial production practices

Table 2. COVID-19 testing, livestock facilities, and COVID-19 incidence

	Dependent variable							
	Case rate				Death rate			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Livestock facility	4.07***	4.30***	4.19***	4.19***	0.07***	0.06**	0.06**	0.06**
	(0.80)	(1.23)	(1.21)	(1.20)	(0.02)	(0.03)	(0.03)	(0.03)
Testing per 1,000			0.01*	0.01*			0.0001**	0.0001**
			(0.003)	(0.003)			(0.0000)	(0.0000)
Positivity rate				0.86**				0.02**
				(0.38)				(0.01)
Controls	X	X	X	X	X	X	X	X
State FE	X	X	X	X	X	X	X	X
Observations	3,032	1,773	1,773	1,773	3,032	1,773	1,773	1,773
R^2	0.45	0.44	0.45	0.45	0.42	0.44	0.44	0.44

Regression model with cross-sectional county-level data from 31 states with livestock facilities and available data on county-level testing gathered from 31 state health departments. Dependent variables are COVID-19 cases (models 1 to 4) and deaths (models 5 to 8) per thousand. Livestock facility is the sum of beef, pork, and poultry plants in the county. Testing per thousand represents the number of tests taken per thousand people in these states as of July 14, 2020. Positivity rate is total cases divided by total tests. Controls include income per capita (log), density (population per built-up land area) and density squared, the number of freight miles traveled, and timing of first case (index of Julian day of first confirmed case), as well as proportions of the county population over the age of 70, Black, Hispanic, public-transit commuters, uninsured, frontline workers, or in nursing homes or prisons. State-level fixed effects (FE) are included in all models. SEs are clustered at state level.

$^{*}P < 0.1$; $^{**}P < 0.05$; $^{***}P < 0.01$.

and microbial control.[‡‡] This finding suggests a need for additional examination of this program.

An implication of this study is that some aspects of large meat-processing plants render them especially susceptible to spreading respiratory viruses. One potential explanation is that large plants simply entail more activity and employ more people. Because these plants provide a central location for moving products, it is plausible that a linear increase in the potential infected within the plant would entail a nonlinear response, owing to the complex and exponential nature of disease-transmission dynamics (70). Another driver may be the large physical spaces where processing occurs. Larger rooms tend to be louder and, thus, require more shouting (53), and they may require stronger climate control, which we note in our introduction may aggravate COVID-19 spread. A larger space that employees must navigate in reaching their workstations may also increase the number of workplace interactions.

More broadly, the finding that meatpacking plants may contribute to high levels of community spread underscores the potential negative public health externalities generated by the industry, which may be attributable to industrial concentration, operating practices, and labor conditions. Complicating this matter from an economic standpoint is the supply-chain choke point created by large plants disrupted by COVID-19, causing food shortages, driving up prices, and incurring substantial upstream and downstream economic losses. Cataloging and addressing the underlying factors that produced this systemic risk in the first place could not only strengthen the US food system in the face of COVID-19 and future disruptions, but also help illuminate analogous weak points in other industries and supply chains.

Materials and Methods

Our analysis used a county-level dataset of COVID-19 cases and deaths from the *New York Times*, based on reports from state and local health agencies (71). Included in counts are both confirmed and probable deaths, as categorized by states. The five county boroughs of New York City are grouped into one unit. We limited the analysis to the continental United States. Our baseline model specification takes the following form:

$$outcome_i = \beta * livestock_i + \theta * controls_i + \alpha_s + \epsilon_i, \quad [1]$$

where $outcome_i$ is the COVID-19 case or death rate in county i, β is the coefficient of interest, $controls_i$ is a vector of county-level covariates, α_s is a dummy for fixed effects in state s, and ϵ_i is the error term.

Covariate data include county-level race, ethnicity, and age structure data from the US Census and mean county-level income data from the US Bureau of Economic Analysis (72, 73). Data on nursing-home populations, incarcerated populations, uninsured populations, average household size, and work-commuting methods come from the 2014–2018 American Community Survey (74–77). Data on manufacturing establishments come from the

Table 3. Livestock facilities and county-level COVID-19 incidence, IV

	Dependent variable			
	Case rate		Death rate	
	(1)	(2)	(3)	(4)
Livestock facility	9.00***	6.12***	0.13*	0.06
	(2.80)	(1.43)	(0.07)	(0.06)
Controls	X	X	X	X
State FE		X		X
Observations	3,032	3,032	3,032	3,032
R^2	0.33	0.45	0.27	0.42

Regression model with an instrument for the presence of a livestock plant in a county using the county's livestock production value in 1959 in terms of animals sold. Livestock facility is the sum of beef, pork, and poultry plants in the county. Controls include income per capita (log), density (population per built-up land area) and density squared, the number of freight miles traveled, and timing of first case (index of Julian day of first confirmed case), as well as proportions of the county population over the age of 70, Black, Hispanic, public-transit commuters, uninsured, frontline workers, or in nursing homes or prisons. State-level fixed effects (FE) are included in models 2 and 4. SEs are clustered at the state level.

$^{*}P < 0.1$; $^{***}P < 0.01$.

[‡‡]In contrast, some plants receiving waivers had recent Occupational Safety and Health Administration violations (42).

American Economic Survey (68). Number of frontline workers were derived from Center for Economic Policy Research data (54), transforming from Public Use Microdata Area-level to the county level, assuming even allocation. The freight index is from the Federal Highway Administration's Freight Analysis Framework (78) using the variable AADTT12, the annual average daily truck traffic in 2012, which we sum across all listed highways in a given county. Data on state-level social-distancing policy come from a dataset synthesizing news articles tracking these policy measures (79–81).

Locations and characteristics of livestock processing facilities come from the USDA FSIS (82). Beef and pork livestock plants were filtered to include plants with volume of all processed products greater than 1 million pounds per month (categories 4 and 5), which account for the vast majority of US production. Poultry livestock were filtered to include plants with volumes greater than 10 million pounds per month (category 5) because that category alone accounts for the majority of US production. County-level mobility data were made accessible to COVID-19 researchers by Google (83). County-level COVID-19 testing data came from a dataset gathered from 31 state health agencies (84). Data on line-speed waivers came from the USDA FSIS (85). Data on plant closures and opening dates came from a dataset assembled from various local news reports, building on a dataset from the Midwest Center for Investigative Reporting (86, 87). Historical livestock-production data are from the 1959 USDA census of agriculture, accessed via the Inter-University Consortium for Political and Social Research (88).

Data Availability. Detailed CSV datasets concerning plant and county-level data relevant to COVID-19 employed in this study are available in Zenodo at https://doi.org/10.5281/zenodo.4069616. Further information is available in Github at https://github.com/cboulos/livestock-covid.

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THE CONVERSATION

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Nearly 1,000 workers at this Smithfield Foods pork-processing plant in South Dakota contracted COVID-19 between mid-March and mid-April 2020. Kerem Yucel / AFP via Getty Images

Meatpacking plants have been deadly COVID-19 hot spots – but policies that encourage workers to show up sick are legal

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Working in meatpacking plants has always been dangerous. A recent study shows that it became deadlier in the era of COVID-19, even as company profits soared.

This analysis, published in December 2020, estimates that 6%-8% of all COVID-19 cases and 3%-4% of all COVID-19 deaths in the U.S. through July 21, 2020 were tied to meat and poultry plants. Workers in these facilities stand close together on processing lines, which makes social distancing difficult.

At the same time, companies like Tyson, which produces chicken, beef and pork, and JBS, which produces beef and pork, are reporting high earnings despite COVID-related challenges such as plant closures.

I am a law professor and have written about links between lax state and federal enforcement of health and safety laws and increased rates of COVID-19 infections and deaths. Thanks to punitive attendance rules and Trump administration policies, meat- and poultry-processing workers have been unnecessarily exposed to COVID-19. In my view, the best way to protect them is to reform laws that prioritize production over workers' health.

Are meatpacking plants keeping essential workers safe?

Meat and poultry workers began calling for better protection early in the COVID-19 pandemic.

Sick on the job

Meat- and poultry-processing companies' standard attendance policies were punitive even before the pandemic. Companies issued points for employees who missed work and fired those who accumulated too many points. These policies are still in place.

Workers at Tyson and JBS plants are required to go to work even if they are experiencing symptoms of COVID-19 or awaiting test results. The companies excuse absences for COVID-19 only if a worker has tested positive for the virus, or in Tyson's case, has "documented clinical symptoms." Tyson and JBS workers have told reporters that costs and wait times make it hard for them to access testing, so they go to work sick.

That said, both companies have taken steps to control the spread of COVID-19 at their plants. Tyson hired medical professionals, cleans its plants daily and monitors social distancing. JBS now offers unlimited personal protective equipment and tests symptomatic workers and close contacts. However, even with safety protocols, the virus can spread in the workplace if infected employees come to work.

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"They will keep going until all of their employees have this virus. They would rather risk their employees' health and keep their production going," a county official wrote last April about a National Beef plant where 250+ had already tested positive.

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Thousands of pages of documents obtained by ProPublica show how quickly public health agencies were overwhelmed by meatpacking ...
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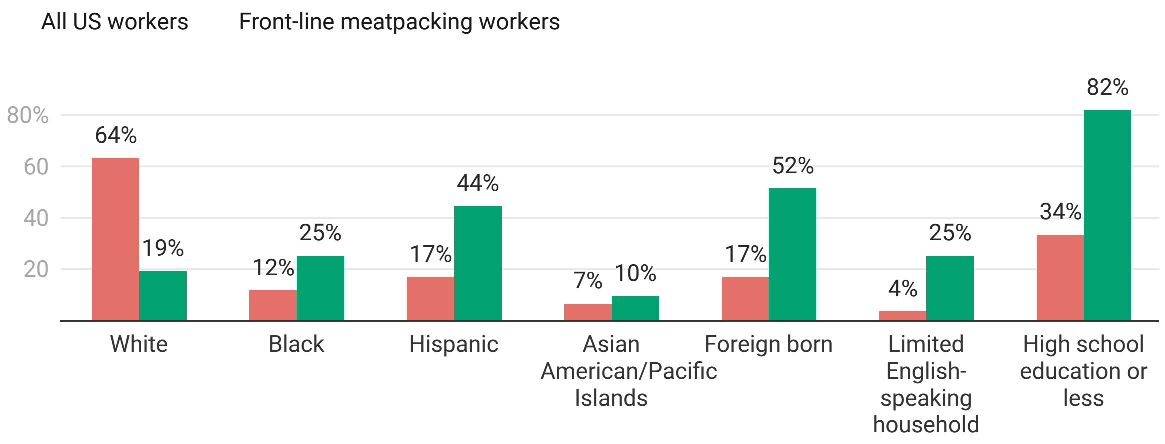
Meat and poultry plants as 'critical infrastructure'

As COVID-19 spread in the spring of 2020, then-President Donald Trump signed an executive order that included language provided by meat trade associations designating meat and poultry plants as critical infrastructure under the Defense Production Act. The order directed the U.S. Department of Agriculture to ensure that meat and poultry processing facilities stayed open or that they reopened as soon as possible during the pandemic to prevent meat shortages.

In May 2020, COVID-19 infections among meat- and poultry-processing workers more than tripled, and the number of deaths quadrupled. Still, with the USDA's help, companies invoked the executive order to maintain operations. For example, in Cold Spring, Minnesota, a Pilgrim's Pride plant that processes chicken stayed open because of Trump's order even though worker infections spiked from 83 on May 8 to 194 on May 11.

Frontline meatpacking workers are disproportionately people of color and immigrants

Workers who handle processing jobs in meat and poultry plants have less formal education than average U.S. workers and are more likely to be Black or Hispanic, born outside the country, and living in a home where English is not the primary language.



Frontline meatpacking workers are defined as people working in the "Animal Slaughtering and Processing Industry" in one of three classifications: Butchers and Other Meat, Poultry, and Fish Processing Workers; Packaging and Filling Machine Operators and Tenders; and Food Processing Workers, All other. Together these groups comprise approximately 194,000 people – over 40% of all workers in the industry.

Chart: The Conversation, CC BY-ND • Source: Center for Economic and Policy Research • Get the data

Profits and lawsuits

On Nov. 17, 2020, Tyson announced net income of US$692 million for the fourth quarter of 2020, up from $369 million for the same period in 2019. Tyson stock traded at $1.81 per share, up 49.5% from the same period in 2019. This was a result of increased production. To date, over 12,500 Tyson workers have been infected with COVID-19.

Tyson currently faces a lawsuit for a COVID-19 outbreak at a plant in Waterloo, Iowa that has sickened at least 1,000 workers and killed five. The wrongful death lawsuit filed by the families of three deceased employees charges that the company required workers – including some who were transferred from facilities with COVID-19 outbreaks – to work long hours in cramped conditions.

For its part, JBS reported $581.2 million in net profits in the third quarter of 2020, beating analysts' forecasts. On Sept. 12, 2020, the U.S. Occupational Safety and Health Administration fined the company $15,615 due to six deaths and 290 COVID-19 infections in its Greeley, Colorado plant.

Commenting on the fine, two former federal regulators noted that the Trump administration could have punished JBS much more severely if it had penalized the company for violations at multiple plants and designated them as willful violations. In November 2020, 32 new infections were confirmed at the Greeley plant.

Legal reforms

Critics argue that the Occupational Safety and Health Administration has not adequately enforced workplace health and safety laws during the pandemic. Trump's executive order limited OSHA's authority to enforce the laws and authorized the Department of Agriculture to keep meat and poultry plants open despite outbreaks. Even with stronger enforcement, however, punitive attendance policies still could increase infection rates by requiring workers to go to work sick.

If confirmed as U.S. secretary of labor, Boston Mayor Marty Walsh would be the first union member to hold the post in nearly 50 years. Graeme Jennings/Pool via AP

President Joe Biden issued an executive order on Jan. 21, 2021, directing the Department of Labor to issue stronger guidance on workplace safety during the pandemic. But employers do not have to comply with this guidance, and it does not address punitive attendance policies.

I believe three reforms are needed to fill the gap. First, federal and state agencies could use their legal authority to prohibit punitive attendance policies. Section 5 of the Occupational Safety and Health Act of 1970 includes a "general duty standard" that requires employers to provide employees with a place of employment free from recognized hazards that are causing or likely to cause death or serious harm.

Although this would be a new use of the "general duty" standard, it would address a recognized hazard that is likely to cause death or serious harm. This is a mandatory requirement that employers already have to comply with and does not require an in-person inspection to enforce.

Second, Biden could withdraw Trump's executive order classifying meat and poultry plants as critical infrastructure. And the Biden administration could require plants to close down if new outbreaks occur among their workers.

Finally, meat and poultry companies could be required to provide workers with hazard pay, which should increase if the companies' net profits rise. As a precedent, Seattle, Long Beach, California and Oakland, California all recently adopted hazard pay mandates for grocery workers during the pandemic.

Grocery store chains are challenging the laws, arguing that their profit margins cannot support these payments. But it would be hard for meat and poultry companies to make that argument in light of their recent earnings.

Meatpacking plants emerged as hot spots of infection early in the COVID-19 pandemic. As of Feb. 24, 2021, more than 57,454 meat- and poultry-processing workers had tested positive for COVID-19 and 284 had died. In my view, it is time for legal action to protect meat and poultry workers and compensate them fairly for working in hazardous conditions during this pandemic.

This article has been updated to note that the estimates cited for COVID-19 illnesses and deaths at meat and poultry plants as a fraction of all U.S. COVID-19 illnesses and deaths covered the period up through July 21, 2020.

Inequality Unions Meat workplace safety Minorities Immigrants Employment law Poultry workplace law Trump administration Occupational safety Occupational Safety and Health Administration COVID-19 Essential workers

ARTICLE Coronavirus US Workers

Meatpacking Workers are a Diverse Group Who Need Better Protections

APRIL 29, 2020

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Yesterday, on Workers Memorial Day, President Trump issued an executive order that requires beef, pork, and poultry producers to continue operating. The executive order also directs the Secretary of Agriculture to issue any additional orders and regulations necessary to keep producers operating. On the same day, the United Food and Commercial Workers reported that there had been at least 20 worker deaths in meatpacking and food processing due to the virus. UFCW also reported that at least 6,500 meatpacking and food processing workers have been directly impacted by the virus — meaning they tested positive for COVID-19 or are awaiting test results, missed work due to self-quarantine, have been hospitalized, and/or are symptomatic — and 22 meatpacking plants have been closed at some point due to the virus so far.

The executive order impacts 194,000 frontline meatpacking workers in the Animal Slaughtering and Processing Industry (see Methodology section below for the three occupations classified as frontline meatpacking occupations). This industry also employs an additional 280,000 workers, most of whom are also directly affected by the order. As this brief shows, frontline meatpacking workers are a diverse group in which people of color and immigrants are overrepresented compared to the US workforce overall. They do dangerous work, even in the best of times, and are poorly compensated for it. The federal government needs to change course and act immediately to provide better protections for these and other essential workers. This includes making many of the optional recommendations issued by the CDC in April mandatory and enforceable, to ensure the safety of both workers and their surrounding communities.

A Basic Demographic Profile of Meatpacking Workers

People of color, immigrants, and people in relatively low-income families are disproportionately employed in meatpacking plants. Almost one-half (44.4 percent) of meatpacking workers are Hispanic, and one-quarter (25.2 percent) are Black.

Across all the occupations of people working in the Animal Slaughtering and Processing Industry, more than half of all workers are people of color (34.9 percent are Hispanic, and 22.5 percent are Black). In some occupations within the industry, more than two-thirds of workers are people of color, including: Hand Packers and Packagers (75.3 percent); Laborers and Freight, Stock, and Material Movers, Hand (68.6 percent); and Industrial Truck and Tractor Operators (67.3 percent).

Immigrants are particularly overrepresented in frontline meatpacking occupations. About 17 percent of workers in the US workforce today are immigrants. But more than one-half (51.5 percent) of frontline meatpacking workers are immigrants. About one-quarter (25.1 percent) of these workers live in households in which all of the members (age 14 or older) have limited proficiency in English, over six times the rate for US workers overall. Other occupations within the Animal Slaughtering and Processing Industry also have a high share of immigrants: Hand Packers and Packagers (52.9 percent); Industrial Truck and Tractor Operators (38.8 percent); and Laborers and Freight, Stock, and Material Movers, Hand (38.2 percent).

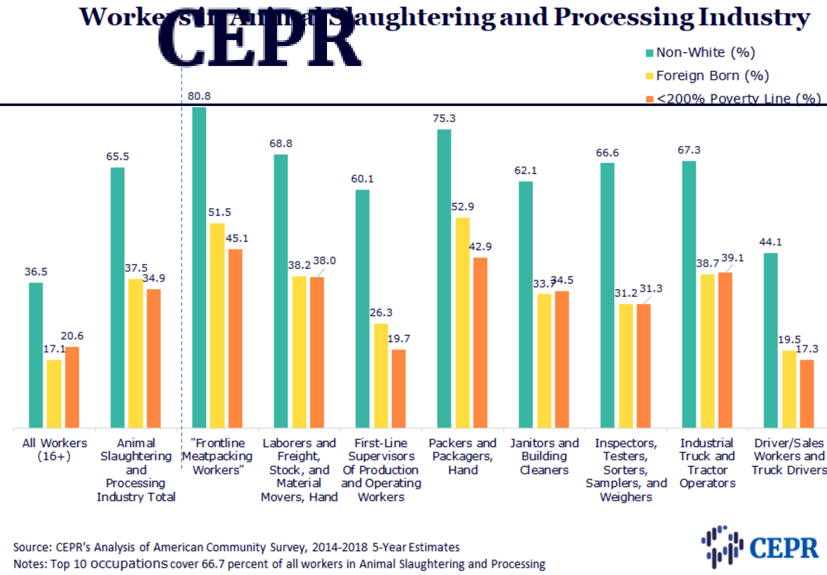
Nearly half of frontline meatpacking workers (45.1 percent) live in low-income families (below 200 percent of the federal poverty line, or less than $52,400 for a family of four in 2020) and about one-in-eight (12.4 percent) have income below the poverty line. This compares to 20.6 percent of all workers from low-income families and 6.7 percent of all workers with income below the poverty level. Meatpacking workers also disproportionately lack health insurance (15.5 percent), have one or more children to care for (44.3 percent), and are less educated (2.5 percent have a college degree or more).

Characteristics of Frontline Meatpacking Workers

		Animal Slaughtering and Processing Industry	
	All Workers	**All Workers**	**Frontline Meatpacking Workers**
All Workers (16+)	152,600,169	473,467	193,996
	(%)	(%)	(%)
Female	47.4	36.2	42.0
Full/Part-time			
Full-time	78.6	94.8	94.0
Part-time	21.4	5.2	6.0
Race/Ethnicity			
White	63.5	34.5	19.1

Black	11.9	22.5	25.2
Hispanic	16.8	34.9	44.4
AAPI	6.6	7.0	10.0
Other	1.2	1.1	1.2
Foreign Born	17.1	37.5	51.5
Limited English Speaking Household	4.0	16.8	25.1
Education Level			
LTHS	9.3	32.6	44.1
HS	24.5	38.3	38.0
Some college	32.0	20.6	15.4
College	21.6	6.7	2.0
Advanced	12.6	1.8	0.5
Child in home	35.8	41.6	44.3
Compensation and Benefits			
Below poverty line	6.7	8.8	12.4
<200% poverty line	20.6	34.9	45.1
No health insurance	11.0	11.8	15.5
Top 10 States, Frontline Meatpacking Workers			
Texas	8.5	7.7	8.3
Georgia	3.1	6.9	7.5
Arkansas	0.9	7.8	7.5
North Carolina	3.1	6.7	7.0
Iowa	1.1	6.1	6.7
Nebraska	0.7	4.7	6.1
California	12.0	4.3	4.1
Missouri	1.9	3.5	3.9
Illinois	4.1	3.9	3.7
Alabama	1.4	3.7	3.4

Source and Notes: CEPR's Analysis of American Community Survey, 2014-2018 5-Year Estimates.



The Federal Government Needs to Do More to Protect Meatpacking Workers

Meatpacking workers exemplify today's diverse, multicultural working class. Even before the pandemic, they did hazardous work on a daily basis with injury and illness rates about two times higher than workers on average. Instead of increasing protections for these workers during the pandemic, the current administration has increased the risks they face. In addition to yesterday's executive order, the United States Department of Agriculture (USDA) has waived federal regulations on maximum line speed in at least 15 poultry plants this month. As documented in recent reporting by USA Today and the Midwest Center on Investigative Reporting, USDA granted more "waivers in one week in April than in any previous month over the past eight years …."

The federal government needs to change course and act immediately to provide better protections for these and other essential workers. For meatpacking workers, these protections must include:

1. guaranteed, free testing on a priority basis;
2. suspending all USDA waivers that allow plants to operate at faster speeds than allowed by federal regulations;
3. ensuring that processing plants enforce physical distancing between workers, even if it means slowing the speed of production;
4. ensuring that all meatpacking workers have necessary personal protective equipment;
5. workers who have or may have COVID-19 stay home;
6. ensuring that all workers who need to stay home due to COVID-19 receive sick pay; and
7. ensuring that meatpacking workers have a voice in their workplaces, including, as recommended in a recent report by Sharon Block and other labor law experts, a "meaningful role in designing and implementing the safety and health protocols that govern their lives on the job."

Methodology

This profile of meatpacking workers uses the most recent five-year estimates of data from the American Community Survey (2014–2018) Public Use Microdata Sample. The demographics of meatpacking workers are unlikely to have changed in any substantial way over the last two years, and using five-year estimates of ACS data helps ensure that sample sizes are sufficient to produce reasonably precise estimates by industry and occupation.

Frontline Meatpacking Workers: "Frontline meatpacking workers" are defined as people working in the "Animal Slaughtering and Processing Industry" in one of these three occupations (as classified using the Census Bureau's Standard Occupational Classification system):

- Butchers and Other Meat, Poultry, and Fish Processing Workers (51-3020)
- Packaging and Filling Machine Operators and Tenders (51-9111)
- Food Processing Workers, All other (51-3099)

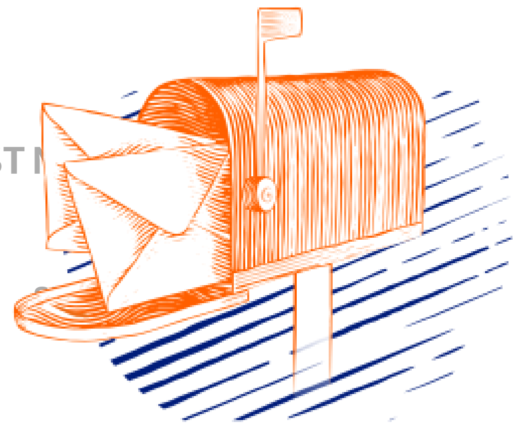
Workers in these three occupations make up more than 40 percent of all workers in the Animal Slaughtering and Processing industry.

Immigrants: Immigrants are defined as foreign-born persons and include naturalized citizens.

Limited English Proficiency: A household has limited proficiency in English if none of the members (age 14 or older) have "good" or "very good" proficiency in English

Poverty: Poverty is defined using the very dated official poverty definition, and does not take account of taxes, work expenses (like child care and commuting costs), various near-cash benefits, and changes in typical living standards (beyond inflation) since the 1960s.

Coronavirus | US | Workers



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Original article

COVID-19 mortality in California based on death certificates: disproportionate impacts across racial/ethnic groups and nativity

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ABSTRACT

Purpose: To examine characteristics of coronavirus disease 2019 (COVID-19) decedents in California (CA) and evaluate for disproportionate mortality across race/ethnicity and ethnicity/nativity.

Methods: COVID-19 deaths were identified from death certificates. Age-adjusted mortality rate ratios (MRR) were compared across race/ethnicity. Proportionate mortality rates (PMR) were compared across race/ethnicity and by ethnicity/nativity.

Results: We identified 10,200 COVID-19 deaths in CA occurring February 1 through July 31, 2020. The most frequently observed characteristics among decedents were age 65 years or above, male, Hispanic, foreign-born, and educational attainment of High School or below. MRR indicated elevated COVID-19 morality rates among Asian/Pacific Islander, Black, and Hispanic groups compared with the White group, with Black and Hispanic groups having the highest MRR at 2.75 (95%CI: 2.54–2.97) and 4.18 (95%CI: 3.99–4.37), respectively. Disparities were larger at younger ages. Similar results were observed with PMR, and patterns of age-racial/ethnic disparities remained in analyses stratified by education. Elevated PMR were observed in all ethnicity/nativity groups, especially foreign-born Hispanic individuals, relative to U.S.-born non-Hispanic individuals. These were generally larger at younger ages and persisted after stratifying by education.

Conclusions: Differential COVID-19 mortality was observed in California across racial/ethnic groups and by ethnicity/nativity groups with evidence of greater disparities among younger age groups. Identifying COVID-19 disparities is an initial step toward mitigating disease impacts in vulnerable communities.

Introduction

There is a growing body of literature on the differential impacts of the coronavirus disease 2019 (COVID-19) in historically marginalized groups in the United States (U.S.), including disease incidence [1-3], hospitalization [4-8], severity [5,9,10], and mortality [3-5,11-13]. Identifying COVID-19 disparities is an initial step toward mitigating disease impacts in vulnerable communities. Much of the current evidence, however, has relied on ecologic analyses using aggregate data for both the characteristic under study (e.g., percentage Black in a county) and COVID-19 outcome (e.g., county-level mortality) [1,3,11,13-15]. Studies that have been conducted with individual-level data are primarily derived from hospital/healthcare networks or insurance companies [2,4,6,7,9,16], which may not be representative of COVID-19 impacts in the gen-

Abbreviations: AI/AN, American Indian/Alaskan Native; A/PI, Asian/Pacific Islander; CA, California; CCDF, California Comprehensive Death Files; CCMDF, California Comprehensive Master Death File; COVID-19, Coronavirus disease 2019; ICD-10, International Statistical Classification of Diseases and Related Health Problems; MR, mortality rates; MRR, mortality rate ratios; PM, proportionate mortality; PMR, proportionate mortality rates; U.S., United States.

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eral population given barriers to healthcare access and insurance among historically marginalized groups. Use of death certificate data allows for investigation into individual-level characteristics, captures all individuals in the catchment area, and does not suffer from substantial under-reporting of key characteristics as was seen for race/ethnicity information for COVID-19 decedents early in the pandemic. It is important to note that any disparities observed for COVID-19 morality are an accumulation of disproportionate impacts along the entire continuum of COVID-19 disease, beginning with exposure to the virus and culminating in death. The mechanisms and magnitudes of disparities likely differ for each step of the disease pathway [17]. Appropriate estimates of disease are needed, not only by single factors, such as racial/ethnic group, but also by intersections with other factors, such as with age, sex, and educational attainment, which considers that groups are not homogenous and indeed reflect diverse experiences and impacts of the pandemic [18-20]. Intersectional analysis allows for a more nuanced understanding of disparate burden of COVID-19, which is crucially needed to design and implement effective public health interventions to mitigate disease impacts.

The objective of this study was to examine demographic characteristics of COVID-19 decedents in California (CA)—which as of September 2020 is among the hardest hit states in terms of cases and deaths [21]—and evaluate for disproportionate mortality across these characteristics. In addition to descriptive information on decedents, COVID-19 mortality was compared across racial/ethnic groups considering age, sex, and education using mortality rate ratios (MRR) and proportionate mortality ratios (PMR). We also examined COVID-19 mortality by ethnicity and nativity combined, considering age and education, with PMR.

Methods

Study setting and population

Data on causes of death, race/ethnicity, sex, age, educational attainment, country of birth, and county of residence were obtained using the California Comprehensive Death Files (CCDF) and California Comprehensive Master Death File (CCMDF) from the California Department of Public Health, Center for Health Statistics and Informatics for 2016 to 2020 (CCMDF for 2016–2018 and CCDF for 2019–2020). Data for 2020 were updated weekly and last date of data export used in this analysis was September 9, 2020. Race/ethnicity were grouped into non-Hispanic White, non-Hispanic Black, Asian/Pacific Islander (regardless of Hispanicity; Asian/PI), American Indian/Alaskan Native (regardless of Hispanicity; AI/AN), Hispanic (excludes A/PI, AI/AN), and Multiracial/Other/Unknown. County of birth was used to define decedents' nativity status, categorized as U.S.-born or foreign-born. Categories of ethnicity and nativity combined were U.S.-born non-Hispanic, U.S.-born Hispanic, Foreign-born non-Hispanic, and Foreign-born Hispanic, using Hispanicity as defined for race/ethnicity. This study was approved by the Committee for the Protection of Human Subjects of the state of CA.

COVID-19-related deaths

Mortality data included the 10th revision of the *International Statistical Classification of Diseases and Related Health Problems* (ICD-10) codes for underlying cause of death and up to 20 relevant conditions. Effective April 1, 2020, there was a new ICD-10 code for COVID-19, U07.1; however, because we used the dynamic CCDF file with weekly updates for recent mortality, final coded data on underlying cause of death and relevant conditions were not available for all 2020 deaths. Thus, we developed an algorithm using the code U07.1 and a keyword search to identify COVID-19-related deaths and applied it to all deaths occurring after February 1, 2020 (eFig. 1). Among deaths with coded data on underlying cause of death and relevant conditions, our algorithm correctly identified 99.95% of deaths coded with U07.1. Analyses were restricted to COVID-19-related deaths occurring February 1-July 31, 2020.

Statistical analysis

Temporal trends in COVID-19 mortality in CA during the study period are presented. Descriptive statistics among decedents identified as having COVID-19 mortality were presented for the entire study period as well as for subperiods with distinct patterns in mortality (i.e., distinct "epidemic periods").

COVID-19 age-adjusted mortality rates (MR) per 100,000 person-years were calculated using direct standardization to the 2019 CA population using 5-year age intervals and were compared across racial/ethnic groups using mortality rate ratios (MRR) by sex and epidemic period, accounting for variation in observation time. Non-Hispanic White was used as the referent group. Population estimates were obtained from the CDC WONDER Online Database using the Bridged-Race Population Estimates for CA [22] and racial/ethnic groups were combined to align with the categories described above (does not include "Multiracial/Other/Unknown" group). Age-adjusted MR were also calculated and compared across racial/ethnic groups using MRR for selected counties with greater than 500 COVID-19 deaths using 2019 county-specific population estimates for both population and direct standardization. COVID-19 age-specific MR were calculated and compared across racial/ethnic groups using MRR by age groups (excluding 0–19 years category, which had only 5 deaths) and sex.

Analyses using proportionate mortality (PM) were restricted to deaths among decedents aged 20 years and older and occurring March 1-July 31 (only 2 COVID-19 deaths occurred before March 1, 2020). PM was defined as number of COVID-19 deaths in a specified subpopulation (e.g., a certain racial/ethnic group) divided by average all-cause mortality in the same subpopulation occurring March 1-July 31 in 2016–2019 among decedents aged 20 years and older (multiplied by 100 to be akin to a percentage). The PM metric allows for COVID-19 mortality to be interpreted as a percentage of "typical" mortality in a group. Mortality for past years was restricted to match the time frame for 2020 COVID-19 deaths to account for annual trends in mortality. All-cause mortality in 2020 was not used as the reference, which would have been common for PM. This is because evidence suggests all-cause mortality has been affected by the pandemic not only through COVID-19 mortality [23]. PM ratios (PMR) were used to compare across decedent characteristics, including racial/ethnic group, sex, educational attainment, and ethnicity and nativity combined, as well as combinations of these. Educational attainment may serve as a proxy for socioeconomic status which is linked with healthcare access, co-morbidities, and other factors such as employment type that may impact COVID-19 infection and mortality [24-27]. Because the PMR metric relies on all-cause mortality, we additionally examined differences in all-cause mortality rates for 2019 by age among racial/ethnic groups using 2019 death data and population estimates.

All analyses were performed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC) and statistical tests were based on 2-sided tests with $\alpha = 0.05$. Standard errors and 95% confidence intervals (95%CI) were computed using standard methods (see eMethods) [28].

Results

We identified 10,200 COVID-19 deaths occurring in CA between February 1 and July 31, 2020. Distinct temporal patterns in weekly

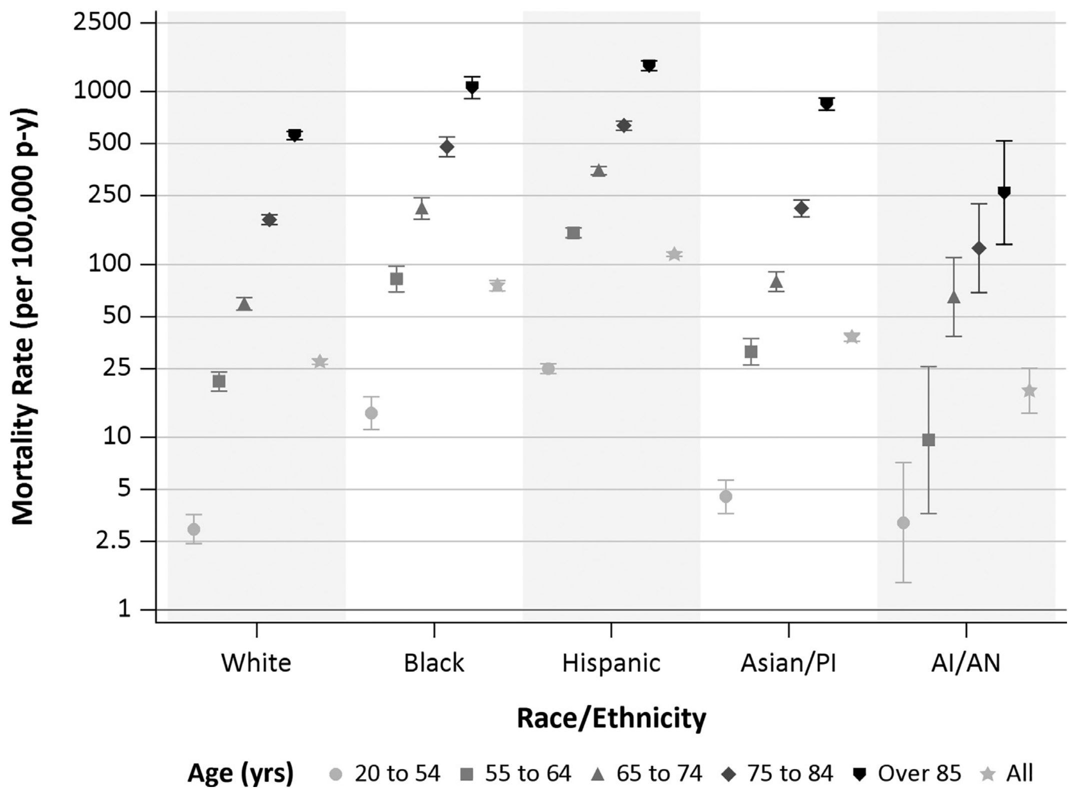

Fig. 1. Age-standardized COVID-19 mortality rates for all ages and select ages by race/ethnicity. Mortality rates are per 100,000 person-years. Bars represent 95% confidence intervals.

mortality identified three periods in the COVID-19 epidemic in CA (eFig. 2): the first period, through April 19, had an upward trend; the second period, April 20–June 16, demonstrated a steady slight decline; the third period, June 17-July 31, had an upward trend similar to the first period. Distribution of characteristics among decedents with COVID-19 mortality are shown for the entire study period (Table 1) and by the three epidemic periods (eTable 1). Decedents were consistently older, more likely to be male, had lower educational attainment, and most were foreign-born. Hispanic was the predominant race/ethnicity among decedents, which increased proportionately during the epidemic.

Mortality rate ratios

Morality rates were considerably higher among older individuals, but with differences observed across racial/ethnic groups (Fig. 1). Compared with the White group, MRR were elevated among Asian/PI, Black, and Hispanic groups, with Black and Hispanic groups having the highest MRR at 2.75 (95%CI: 2.54–2.97) and 4.18 (95%CI: 3.99–4.37), respectively (Fig. 2 and eFig. 3; eTable 2). This pattern persisted within each epidemic period (eFig. 3). Analyses by county of residence for counties with greater than 500 COVID-19 deaths (Los Angeles, Orange, Riverside, San Bernardino, and San Diego Counties) showed that while there were some differences in specific MRRs estimated by racial/ethnic group, the overall pattern of COVID-19 mortality disparity persisted (eFig. 4).

Age-specific MRR revealed greater differences among racial/ethnic groups, with greater disproportionate mortality among younger Black and Hispanic individuals (Fig. 2; eTable 3). Compared with White individuals aged 20–54 years, the MR was 4.7-fold (95%CI: 3.5–6.3) higher among Black individuals and 8.5-fold (95%CI: 6.9–10.4) higher among Hispanic individuals of the same age. When examined by sex, disparities observed among decedents aged less than 84 years were higher among females in the Black group and among males in the Hispanic group. In the Asian/PI group, mortality disparity was greatest among those aged 85 year or more, with the largest MRR observed for females, 1.70 (95%CI: 1.50–1.93).

Proportionate mortality

Univariate analyses using PMR found elevated PM in males compared with females, in all non-White racial/ethnic groups, in decedents with lower educational attainment, and in all ethnicity/nativity groups relative to U.S.-born non-Hispanic (eTable 4).

Analyses comparing across racial/ethnic groups by age demonstrated greater disparities among younger decedents, similar to those observed with MRR (eTable 5). Elevated PMR persisted in analyses stratified by education (Fig. 3; eTable 6). For example, among decedents aged 20–64 years with high school education or less, the PM in the Hispanic group was 8.5-fold (95%CI: 7.4–9.9) higher compared with the White group. For the same age group, but among those with some college or more, the PMR for Hispanics remained highly elevated at 7.0 (95%CI: 5.8–8.6). All-cause mortality rates for 2019 were lower compared with the White group for all racial/ethnic group, except the Black group which were higher. This may lead PMR to over or underestimate true COVID-19 mortality disparities which should be considered when interpreting these results These differences, however, were not sufficiently large to explain away all disparities observed (eFig. 5). Adjusting PMR for differences in all-cause mortality produces estimates similar to MRR reported above (eTable 7).

When examining ethnicity and nativity combined by age, elevated PMR were observed for all groups, especially for the foreign-born Hispanic group, relative to the U.S.-born non-Hispanic group (eTable 8). PMR were generally larger among younger age groups. After accounting for educational attainment by stratification, el-

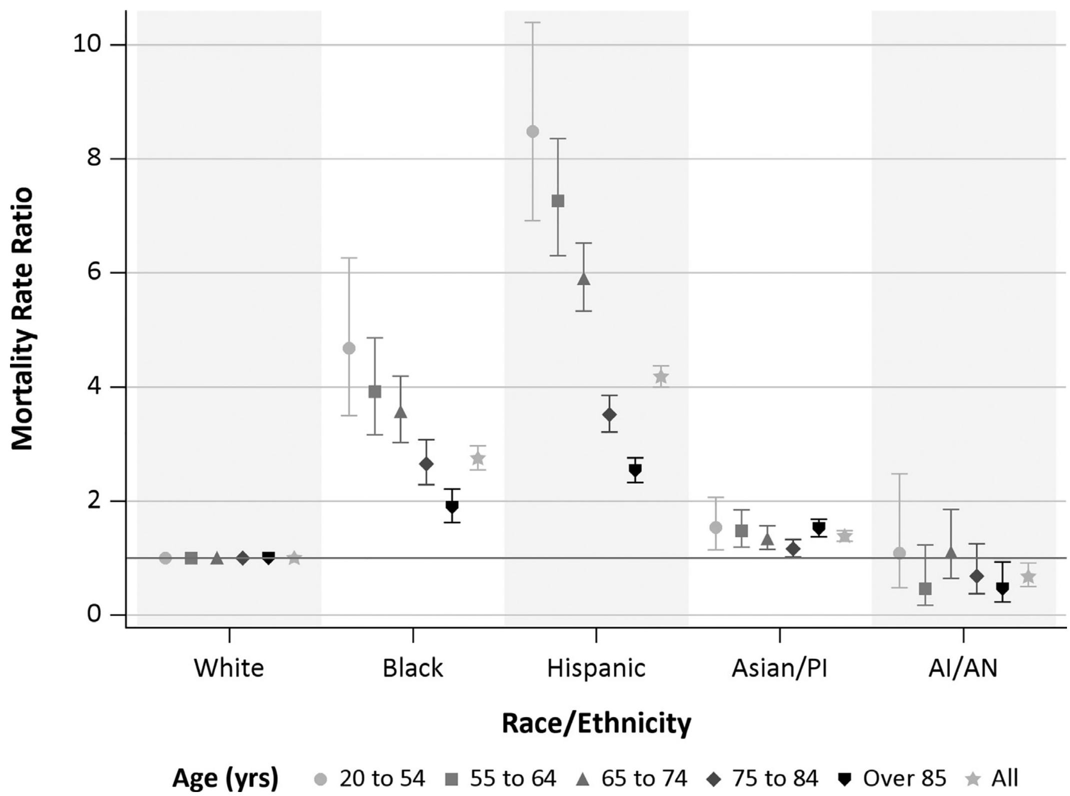

Fig. 2. Age-standardized COVID-19 mortality rate ratios for all ages and select ages by race/ethnicity. Bars represent 95% confidence intervals. Referent group is non-Hispanic Whites.

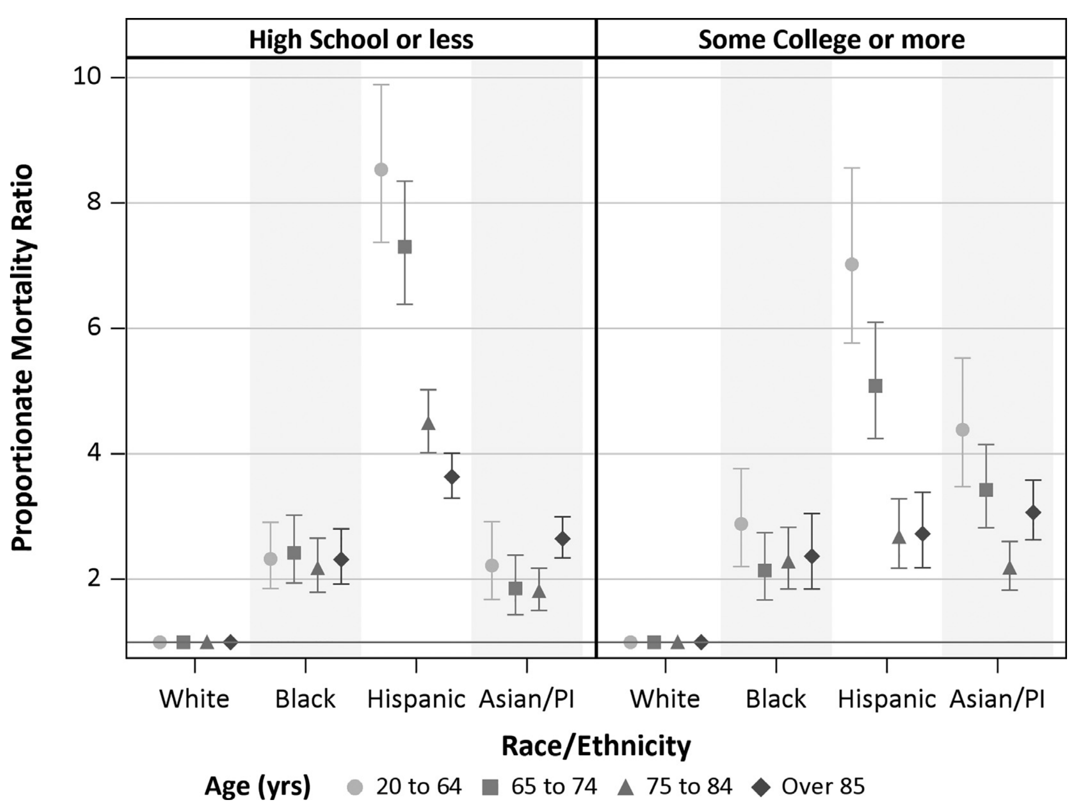

Fig. 3. Proportionate mortality ratios for COVID-19 by race/ethnicity, age, and educational attainment. Proportionate mortality ratios are based on COVID-19 deaths occurring between March 1-July 31, 2020 among decedents aged 20 years and older. Subpopulation proportionate mortalities were calculated using all-cause mortality in the same subpopulation occurring March 1–July 31 in 2016–2019 among decedents aged 20 years and older. Bars represent 95% confidence intervals. Referent group for PMR is non-Hispanic White.

Table 1
Distribution of selected characteristics among decedents identified as having COVID-19 mortality, California, February 1–July 31, 2020

	N (%)
Deaths	10,200
Age	
0–19	5 (0.1)
20–44	421 (4.1)
45–54	710 (7.0)
55–64	1467 (14.4)
65–74	2222 (21.8)
75–84	2450 (24.0)
85 or older	2925 (28.7)
Sex	
Male	5914 (58.0)
Female	4286 (42.0)
Race/ethnicity	
Hispanic (excludes A/PI, AI/AN)	4914 (48.2)
Mexican	*3333 (67.8)*
Other Hispanic	*1581 (32.2)*
NH White	3025 (29.7)
Asian/Pacific Islander	1290 (12.7)
Filipino	*441 (34.2)*
Chinese	*251 (19.5)*
Korean	*207 (16.1)*
Vietnamese	*97 (7.5)*
Japanese	*82 (6.4)*
Other Asian	*212 (16.4)*
Black	804 (7.9)
Multiracial/other/unknown	124 (1.2)
American Indian/Alaskan Native	43 (0.4)
Educational Attainment	
Less than high school	3637 (35.7)
High school	3027 (29.7)
Some college	1040 (10.2)
Associate degree	478 (4.7)
Bachelor's degree	966 (9.5)
Graduate degree	499 (4.9)
Unknown	553 (5.4)
Country of birth	
United States	4413 (43.3)
Mexico	2942 (28.8)
Philippines	442 (4.3)
El Salvador	364 (3.6)
Guatemala	219 (2.2)
South Korea	195 (1.9)
Other country	1302 (12.8)
Unknown	323 (3.2)

evated PMR remained (Table 2). Among decedents aged 20–64 years, PMR for foreign-born Hispanic compared with U.S.-born non-Hispanic among those with a high school education or less was PMR = 10.7 (95%CI: 9.5–12.1), while among those with some college or more was PMR = 8.4 (95%CI: 6.9–10.1).

Discussion

This study used death certificate data to identify decedents with COVID-19 mortality in CA and to investigate demographic characteristics associated with mortality using two different metrics of association, MRR and PMR. Disproportionate COVID-19 mortality was observed among Black, Hispanic, and Asian/PI groups in CA. Larger relative disparities were observed at younger ages for Black and Hispanic individuals. Disparities persisted after accounting for educational attainment, serving here as a proxy for socioeconomic status. Disproportionate mortality was also observed by combinations of ethnicity and nativity, with all groups (especially foreign-born Hispanic individuals) having greater COVID-19 mortality compared with U.S.-born non-Hispanic individuals, particularly at younger ages. Disparities by nativity remained in analyses controlling for educational attainment. The larger disparities in younger age groups are particularly important given younger populations may be overlooked in public health campaigns due to their overall lower risk of severe disease. Here, however, we observed the mortality rate for Black individuals aged 55–64 to be higher than mortality rate for White individuals 10 years older, and the mortality rate for Hispanic individuals aged 55–64 years to be approaching mortality rate for White individuals 20 years older. The much larger disparities observed in MRR for Hispanic individuals compared with Black individuals, for all ages but particularly for younger ages, are likely driven in part by the high COVID-19 mortality observed for foreign-born Hispanic individuals. Younger populations should be included among targets in public health interventions. Disparities in COVID-19 mortality may be driven by a variety of factors, including complex interaction between social and structural determinates of health, barriers to accessing care, higher prevalence of underlying co-morbidities associated with more severe COVID-19 disease and adverse outcomes, and differential exposure to virus due to working and living conditions [24,29-34]—which maybe different and interact differently among the different groups (race/ethnicity and ethnicity/nativity) and subgroups (age-race/ethnicity and age-ethnicity/nativity groups) examined here.

Table 2
Proportionate mortality (PM) and proportionate mortality ratio (PMR) by ethnicity and nativity combined, age, and educational attainment for COVID-19 deaths among decedents aged 20 years and older, California, March 1–July 31, 2020

		High school or less			Some college or more		
Ethnicity and nativity combined	Age	COVID-19 Deaths	PM (95% CI)[a]	PMR (95% CI)	COVID-19 Deaths	PM (95% CI)[a]	PMR (95% CI)
U.S.-born non-Hispanic	20 to 64	295	3.6 (3.2–4.0)	Referent	223	3.1 (2.7–3.5)	Referent
	65 to 74	309	5.7 (5.1–6.3)	Referent	315	4.3 (3.8–4.8)	Referent
	75 to 84	441	6.1 (5.6–6.7)	Referent	468	5.4 (4.9–5.9)	Referent
	85<=	602	4.9 (4.6–5.3)	Referent	532	4.4 (4.0–4.8)	Referent
U.S.-born Hispanic	20 to 64	272	10.1 (9.0–11.4)	2.81 (2.40–3.29)	130	10.4 (8.8–12.4)	3.40 (2.76–4.18)
	65 to 74	170	18.1 (15.6–21.1)	3.20 (2.69–3.80)	67	13.0 (10.2–16.5)	3.06 (2.39–3.92)
	75 to 84	166	14.0 (12.0–16.3)	2.29 (1.94–2.71)	40	9.2 (6.8–12.6)	1.71 (1.26–2.33)
	85<=	236	12.1 (10.7–13.8)	2.46 (2.13–2.84)	33	8.6 (6.1–12.1)	1.96 (1.40–2.74)
Foreign-born non-Hispanic	20 to 64	84	6.7 (5.4–8.4)	1.87 (1.48–2.37)	138	7.9 (6.7–9.3)	2.57 (2.09–3.16)
	65 to 74	109	9.3 (7.7–11.2)	1.63 (1.32–2.01)	180	11.5 (10.0–13.4)	2.71 (2.27–3.23)
	75 to 84	224	10.0 (8.8–11.4)	1.63 (1.40–1.90)	207	9.5 (8.3–10.9)	1.77 (1.51–2.07)
	85<=	506	12.1 (11.1–13.2)	2.46 (2.20–2.75)	265	10.1 (8.9–11.4)	2.30 (1.99–2.64)
Foreign-born Hispanic	20 to 64	1177	38.7 (36.6–41.0)	10.73 (9.51–12.11)	161	25.6 (21.9–29.9)	8.35 (6.93–10.05)
	65 to 74	792	45.2 (42.1–48.4)	7.96 (7.06–8.98)	94	31.5 (25.7–38.5)	7.39 (6.06–9.02)
	75 to 84	691	32.4 (30.1–35.0)	5.31 (4.76–5.92)	59	19.2 (14.9–24.7)	3.55 (2.78–4.54)
	85<=	547	23.7 (21.8–25.8)	4.80 (4.31–5.34)	50	15.2 (11.5–20.0)	3.46 (2.64–4.52)

[a] Subpopulation PM were calculated using all-cause mortality in the same subpopulation occurring March 1–July 31 in 2016–2019 among decedents aged 20 years and older.

Differences in COVID-19 mortality can develop anywhere along the disease continuum from exposure, to incidence, severity, and then ultimately death. The mechanisms and magnitude of these difference are likely different for different groups (e.g., younger Black group, older Asian/PI, etc.) at different points along the pathway. Several studies have reported differential COVID-19 impacts across racial/ethnic groups including for incidence [1,35], severity [4-6,8-10], death [12,13,27], however few studies have examined outcomes by nativity [36]. Ecologic studies have reported COVID-19 incidence rates to be positively associated with higher population percentage Black [14,26,37], Hispanic/Latino [15,26,34,37], or foreign-born [26,37]. In a Massachusetts study the association for Latino population percentage was attenuated after accounting for percent foreign-born noncitizens living in a community, mean household size, and share of food service workers (all which were also positively associated with incidence) [37]. In contrast, the association for Black population percentage was not attenuated [37]. In a study across 22 states, a disproportionate number of incident COVID-19 cases relative to population demographics was reported for Hispanic, Black, AI/AN, Asian, and Native Hawaiian/Pacific Islander individuals in counties considered hotspots for COVID-19 incidence [1]. Healthcare system-based studies have reported greater severe acute respiratory syndrome coronavirus 2 testing and test positivity rate for non-English speakers compared with English-speakers [36] and higher odds of infection for non-Hispanic Black and Hispanic individuals adjusting for demographic and socioeconomic characteristics [35]. Higher hospitalization has been reported for Black and Hispanic patients, even after adjusting for co-morbidities and demographic and socioeconomic factors [4,6,8]. Among patients hospitalized with COVID-19 infection, non-White patients were more likely to present with higher disease severity, which was associated with worse outcomes [10].

These disproportionate effects in disease incidence and severity contribute to COVID-19 mortality disparities, which have been reported based on aggregate data or healthcare system-based studies for Black and Hispanic individuals. A study using aggregate data on COVID-19 from regions across the U.S. report disproportionately higher COVID-19 mortality relative to population size for Black individuals and higher estimated case-fatality [12]. Among rural counties, average daily increase in COVID-19 mortality rates were significantly higher in counties with the largest shares of Black and Hispanic residents [13]. A study using electronic medical record data from 24 healthcare organization reported Black individuals having a greater odds of COVID-19 mortality, even after controlling for age, sex, and several co-morbidities [27]. Differences between Black and White individuals were larger in those less than 50 years of age, similar to larger MRR and PMR observed in younger age groups in the present study. Not all studies examining race/ethnicity have observed difference in COVID-19 mortality. A large study using data from 92 U.S. hospitals found that after adjusting for a variety of factors including comorbidities, insurance, and neighborhood deprivation there was no difference in mortality between Black and White patients with COVID-19 [7]. Similarly, a study in Louisiana found that after adjusting for sociodemographic and clinical factors, in-hospital mortality was not different between Black and White patients [4]. It may be that once COVID-19 patients are ill to the point of hospitalization, differences in mortality are less appreciable. Overall, this evidence taken together supports the notion that mortality differences across racial/ethnic groups and by ethnicity/nativity reported in the present study are likely the cumulative effects across the entire pathway of disease.

Quantification of COVID-19 mortality disparities is needed so effective public health interventions can be developed to mitigate disproportionate burden of the pandemic on vulnerable populations [38]. Factors that may contribute to mortality disparities and could be targets for interventions include barriers to healthcare access including medical mistrust and insurance, living and working conditions, being essential/frontline workers, underlying health conditions including suboptimal disease management, and social and structural determinants of health [24,29-33,39]. Interactions between structural, social, and individual factors that contribute to differential COVID-19 mortality are complex and vary not only across these different historically marginalized groups (e.g., Black, Hispanic, Asian/PI, foreign-born Hispanic), but also within these groups (e.g., younger and older Hispanic individuals). Public health interventions and policies should consider the differing and complex risk structure across and within these groups. For example, differential workplace exposure may contribute to increased mortality among younger Black and Hispanic, including foreign-born Hispanic, individuals. People of color are more likely to be employed in essential industries and in occupations with more exposure to infections and close proximity to others [30]. Black workers in particular face an elevated risk for these factors [30]. A study of workplace COVID-19 outbreaks in Utah found 73% of cases were in Hispanic or non-White workers, whereas Hispanic and non-White workers represent only 24% of the workforce in affected industries [33]. Immigrant families faced additional complicating factors (e.g., employment in jobs with higher potential exposure, no/inadequate health insurance and paid leave, multigenerational housing, etc. [40,41]) which must be considered for public health planning. For example public charge regulations may have disincentivized immigrant families from accessing healthcare if they become symptomatic [40,41]. This delays testing and treatment and may increase disease transmission risk within their home and communities [40,41].

This study has limitations. First, while use of death certificate data has many advantages, there were a limited number of available demographic and socioeconomic variables. Augmentation of these data with neighborhood characteristics based on decedent residential address is an area of future work. Second, the variable related to socioeconomic position used in this analysis—educational attainment—is only one dimension of person's socioeconomic status and does not fully capture this complex determinant of health. Further, there may be misreporting of educational attainment on death certificates, with prior studies finding higher underreporting of educational attainment for Black and Hispanic decedents compared with White decedents [42]. This is also likely for foreign-born individuals. Any differential misreporting, however, would be expected to lead to less misclassification among Black and Hispanic (and possibly also foreign-born) decedents categorized as "Some college or more" yet large mortality disparities persisted in stratified analyses. Third, PM, and thus PMR, uses as a comparison all-cause mortality, which if different between groups may over or underestimate differences in mortality between groups. When all-cause mortality rates are lower compared with the referent group, PMR will overestimate differences in COVID-19 mortality, but as discussed differences in all-cause mortality rates were not sufficient to explain all observed COVID-19 disparities. When all-cause mortality rates are higher, such as was observed for Black individuals, the PMR will underestimate differences COVID-19 mortality. This study has several strengths. First, to identify COVID-19 mortality we used death certificate data which captures all mortality in the state and does not restrict to individuals in a healthcare/insurance network. Second, we had information on individual-level demographic characteristics on decedents, which was advantageous in two regards: (i) there was substantial under-reporting of race/ethnicity for COVID-19 decedents early in the pandemic and there is still a lack of reporting by nativity, which precludes analyses by these factors, and (ii) we did not have to rely on aggregate demographic data which could be subject to the ecologic fallacy. Third, because of this individual-level data we were able to examine mortality by several demographic factors in combination to better understand intersectional impacts of COVID-19.

Conclusions

Differential COVID-19 mortality was observed in California across racial/ethnic groups and by ethnicity and nativity combined, with evidence of greater disparities among younger age groups. Patterns of disparities persisted after accounting for educational attainment. Drivers of these disparate COVID-19 impacts are likely multifactorial and involve the interplay of structural, social, and individual factors that must be considered in the design and implementation for public health interventions to effectively mitigate the impacts of this disease.

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