

US Foreign-Born Workers in the Global Pandemic: Essential and Marginalized

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Executive Summary

This article provides detailed estimates of foreign-born (immigrant) workers in the United States who are employed in “essential critical infrastructure” sectors, as defined by the Cybersecurity and Infrastructure Security Agency (CISA) of the US Department of Homeland Security (DHS) (DHS 2020). Building on earlier work by the Center for Migration Studies (CMS), the article offers exhaustive estimates on essential workers on a national level, by state, for large metropolitan statistical areas (MSAs), and for smaller communities that heavily rely on immigrant labor. It also reports on these workers by job sector; immigration status; eligibility for tax rebates under the Coronavirus Aid, Relief, and Economic Security Act (CARES Act); and other characteristics. It finds that:

- Sixty-nine percent of all immigrants in the US labor force and 74 percent of undocumented workers are essential workers, compared to 65 percent of the native-born labor force.
- Seventy percent of refugees and 78 percent of Black refugees are essential workers.
- In all but eight US states, the foreign-born share of the essential workforce equals or exceeds that of all foreign-born workers, indicating that immigrant essential workers are disproportionately represented in the labor force.
- The percentage of undocumented essential workers exceeds that of native-born essential workers by nine percentage points in the 15 states with the largest labor force.
- In the ten largest MSAs, the percentages of undocumented and naturalized essential workers exceed the percentage of native-born essential workers by 12 and 6 percent, respectively.
- A total of 6.2 million essential workers are not eligible for relief payments under the CARES Act, as well as large numbers of their 3.8 million US citizen children (younger than age 17), including 1.2 million US citizen children living in households below the poverty level.
- The foreign-born comprise 33 percent of health care workers in New York State, 32 percent in California, 31 percent in New Jersey, 28 percent in Florida, 25 percent in Nevada and Maryland, 24 percent in Hawaii, 23 percent in Massachusetts, and 19 percent in Texas.

Section I of the article describes the central policy paradox for foreign-born workers during the COVID-19 pandemic: that they are “essential” at very high rates, but many lack status and they have been marginalized by US immigration and COVID-19-related policies. Section II sets forth the article’s main findings. Section III outlines major policy recommendations.

Keywords

essential workers, COVID-19, United States, immigrants, Department of Homeland Security

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I. Foreign-Born Workers and COVID-19: The Policy Context

Scholars have abundantly documented the contributions of immigrants to the US labor force and economy, but these contributions remain poorly acknowledged in US political discourse. Foreign-born participation rates in the labor force have long exceeded those of the native-born (BLS 2019). Immigrants fill gaps in the US economy, improve labor market efficiency, and support the aging US population (Sherman et al. 2019). Immigration has also “brought to the United States an inordinate share of the world’s best talent which has been a windfall in a global economy where heavy advantages accrue to the most innovative companies and countries” (CFR 2009).

As immigrants progress to permanent residence and naturalization, they contribute more significantly to US communities and the nation (Kerwin and Warren 2019). Yet the Trump administration has sought to strip several populations of legal status and to decrease legal immigration through a laundry list of administrative measures (*ibid.*). The administration has repeatedly argued that immigrants displace and diminish the prospects of native-born workers, a notion that rests on the “fundamental misconception that there is a fixed amount of work in society” (Nowrasteh 2020) and that ignores the myriad ways immigrants create jobs.

The administration has designated many immigrant-dense sectors “essential,” but has failed to make Centers for Disease Control and Prevention (CDC) guidelines for safeguarding these workers enforceable, or to offer hazard pay, access to health care, assistance with child care, temporary housing (as necessary), or other needed assistance to them (Evich and Crampton 2020). Instead, it has used the pandemic to reduce workplace protections for essential workers, particularly immigrants (Mayer 2020), and to restrict legal immigration and refugee admissions (Trump 2020a, 2020b).

Moreover, at the peak of foreign-born workers acknowledged importance to the country, the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) denied federal tax rebates to persons who filed tax returns without a “valid identification number” (defined as a Social Security number) or, in the case of a joint return, if either spouse lacked a Social Security number.¹ US residents who filed their taxes with Individual Taxpayer Identification Numbers (ITINs) did not qualify for

benefits. Yet ITIN filers pay more than \$9 billion in withheld payroll taxes annually and contribute to the solvency of federal retirement programs (Hallman 2018). The CARES Act excluded most US taxpaying, mixed-status families — with undocumented and US citizen members (typically children) — from obtaining badly needed financial relief.

US Citizenship and Immigration Services (USCIS) has announced that “medical treatment or preventive services” for COVID-19 or symptoms that resemble COVID-19 will not be held against immigrants under the new “public charge” rule, when they seek to adjust to permanent residence (USCIS 2020). In addition, it has vowed to take into “consideration” evidence that COVID-19 or related policies caused the use of public benefits or influenced other “relevant” factors in a public charge determination (*ibid.*).

The administration has refused to suspend the public charge rule during the pandemic, although in late July of 2020 a federal court enjoined enforcement of the rule during the national health emergency. Nonetheless, there have been numerous reports of immigrants and their family members — sick with COVID-19 — who refuse to access health services or benefits for fear that doing so would compromise their ability or that of family members to obtain permanent residence (Hlavinka 2020; Raff 2020). This chilling effect appeared even prior to the pandemic and implementation of the new rule. A team of scholars from the Urban Institute found “a statistically significant increase (from 21.8 percent to 31.0 percent)” between 2018 and 2019 in chilling effects among adults in immigrant families in which at least one member was not a permanent resident (Bernstein et al. 2020, 4).² Beyond longstanding barriers to immigrants accessing public programs, the study concluded that the new rule’s “complexity — along with the broader enforcement-oriented immigration policy climate — raises additional barriers and may have spillover effects

¹Coronavirus Aid, Relief, and Economic Security Act (CARES Act), §2201, Pub. L. No. 116-136 (2020). <https://www.congress.gov/bill/116th-congress/house-bill/748/text>.

²The study defined chilling effect as “not applying for or stopping participation in a noncash government benefit program . . . within the previous 12 months because of concerns that the respondent or their family member could be disqualified from obtaining a green card” (Bernstein et al. 2020, 13).

on families and programs not targeted by the rule” (ibid., 4).

This article shows that the foreign-born work at high rates in the US “essential critical infrastructure” workforce — such as in meatpacking and poultry processing, agricultural work, health care, construction, child care, and critical retail — as defined by DHS’s Cybersecurity and Infrastructure Security Agency (DHS-CISA 2020).³ The federal government, states, and localities have acknowledged the crucial contributions of these workers, many of whom risk their lives as “front-line” responders. Federal guidelines seek to promote the ability of essential workers “to continue to work during periods of community restriction” (ibid.). States, in turn, have produced template letters for use by critical infrastructure employers and employees that seek to ensure that essential workers can travel to and from work, and can carry out their job responsibilities without interference from public officials (Suro and Findling 2020).

COVID-19 has exacted a grim toll on immigrants and other vulnerable communities. Several industries with large numbers and substantial rates of foreign-born workers have experienced high rates of infection. According to the Midwest Center for Investigative Reporting, as of August 25, 2020, a reported 37,500 workers in 416 meatpacking plants in 40 states had tested positive for COVID-19, and “at least” 170 workers had died (Chadde 2020). These figures almost certainly undercount the numbers of meatpacking plant workers who have contracted COVID-19 and who have died from related complications.

On April 26, the CDC and the Occupational Safety and Health Administration (OSHA) issued interim guidance, with a series of recommendations, on how meatpacking and poultry-processing facilities can safeguard workers from infection, reduce COVID-19’s spread, and prepare for their recovered workers to return to work (CDC and OSHA 2020). This nonbinding guidance makes it exceedingly difficult for workers to prevail in legal challenges to unsafe working conditions by stipulating that “some employers may face difficulties complying with certain OSHA standards due to the ongoing health emergency” and that OSHA will

evaluate employers on whether they have made “a good faith effort to comply with applicable OSHA standards” (ibid.). Despite the risk to workers — indeed, because of closures and the reduced capacity of meatpacking and poultry-processing facilities due to worker illness — the president subsequently delegated the Secretary of Agriculture to “take all appropriate action” to ensure that these “essential infrastructure” continue their operations (Trump 2020b). Many have harshly criticized the administration’s actions as valuing production over lives and of using the pandemic to advance goals, such as weakened workplace protections, that it has long championed (Axon, Bagenstose, and Chadde 2020). OSHA has failed to act on thousands of workplace complaints related to COVID-19 (Mayer 2020).

Migrant farmworkers have also been hard hit. In Immokalee, Florida, for example, 1,910 persons had tested positive for COVID-19 by July 20 (Florida Department of Health 2020), the overwhelming majority of them agricultural workers for whom social distancing, at home or at work, can be difficult, if not impossible (Reiley 2020). Agricultural workers in New York, Washington, North Carolina, and California have also suffered large-scale outbreaks (Evich and Crampton 2020). In short, immigrants have been on the front lines in stemming the spread of COVID-19, disproportionately represented among its victims, and mostly left by the federal government to fend on their own with unsafe working conditions and the economic downturn.

II. Findings

Based on 2018 US Census Bureau data, the Center for Migration Studies (CMS) estimates that 19.8 million immigrants (69 percent) work in “essential critical infrastructure” sectors (DHS-CISA 2020),⁴ compared to 65 percent of the native-born labor force (Table 1). Essential workers make up a larger share (74 percent) of all undocumented workers than the native-born or legally resident populations; that is, undocumented workers supply relatively more essential workers during the pandemic. As column 7 in Table 1 shows, the share of undocumented workers that are essential exceeds the

³Forty-two states have also issued essential worker orders and directives (NCSL 2020). Twenty of these states defer to CISA’s guidance and essential worker definitions (ibid.).

⁴An earlier CMS report produced estimates of immigrants in New York State working in “essential businesses,” as determined by the state (not DHS) (Nicholson and Alulema 2020). CMS has also reported on the high number of DACA beneficiaries in select essential industries (Alulema 2020).

Table 1. Percentage of the Labor Force That Are Essential, and Comparisons between Native-Born and Immigrants, by Legal Status: 15 States Ranked by Size of the Labor Force.

State of residence	Percentage of workers deemed essential (16+)				Difference from native-born		
	Native-born (1)	Naturalized (2)	Legal noncitizens (3)	Undocumented (4)	Naturalized (5)=2-1	Legal noncitizens (6)=3-1	Undocumented (7)=4-1
Total workers	135,978	14,301	7,041	7,427	—	—	—
Essential	65%	67%	66%	74%	2%	-2%	9%
California	61%	66%	66%	73%	6%	0%	6%
Texas	65%	67%	67%	77%	2%	0%	11%
Florida	64%	67%	69%	75%	3%	2%	7%
New York	61%	69%	67%	74%	8%	-2%	7%
Illinois	64%	69%	64%	72%	5%	-5%	8%
Pennsylvania	67%	67%	62%	71%	0%	-5%	9%
Ohio	68%	67%	63%	72%	0%	-5%	10%
Georgia	65%	64%	60%	73%	0%	-5%	14%
North Carolina	65%	63%	63%	73%	-2%	1%	10%
Michigan	68%	71%	66%	74%	3%	-5%	8%
New Jersey	62%	66%	63%	69%	4%	-2%	6%
Virginia	63%	61%	60%	75%	-2%	-2%	15%
Washington	64%	68%	62%	75%	3%	-5%	13%
Massachusetts	62%	69%	65%	69%	8%	-4%	4%
Arizona	65%	71%	69%	77%	6%	-1%	8%
All other	67%	68%	65%	77%	2%	-4%	12%

Source: Center for Migration Studies. See text for data and methods.

native-born share by about nine percentage points. In many states, this disparity is even more pronounced (Table 1). These workers meet the health, infrastructure, manufacturing, service, food, safety, and other needs of all Americans. Roughly one-half of US foreign-born essential workers — 9.6 million — are naturalized citizens, 4.6 million are legal noncitizens (mostly lawful permanent residents or LPRs), and 5.5 million are undocumented (Appendix, Table A).⁵

‘In all but eight states, the foreign-born share of the essential workforce equals or exceeds the overall foreign-born share of state workers, (Appendix, Table A). In California, immigrants comprise 36 percent of essential workers. In New York and New Jersey, they

comprise 31 percent of essential workers. In Florida and Nevada, they make up 28 and 27 percent of essential workers, respectively. They also account for more than 20 percent of essential workers in Texas (24 percent), Hawaii (24 percent), Massachusetts (23 percent), and Maryland (21 percent). Foreign-born essential workers work at high rates in several of the states experiencing the most significant percentage increases in new COVID-19 cases as of late-August 2020 (Adeline et al. 2020; CDC 2020), including California (36 percent), Florida (28 percent), and Texas (24 percent).

In the five states with the largest labor force, a relatively higher percentage of naturalized citizens are essential workers, compared to the native-born (Table 1). In California, 66 percent of naturalized workers are essential compared to 61 percent of native-born workers. In New York, 69 percent of naturalized workers are essential, compared to 61 percent of native-born workers.

Table 2 shows the percentages of immigrant essential workers by status in the labor force in the ten largest US

⁵CMS’s undocumented estimates include two legally present populations, Deferred Action for Childhood Arrivals (DACA) and Temporary Protected Status (TPS) recipients. Nearly one-half of all US foreign-born essential workers are naturalized citizens, 28 percent are undocumented, and 23 percent are legal noncitizens.

Table 2. Percentage of the Labor Force That Are Essential, by Legal Status: Top 10 Metropolitan Areas by Population (numbers in thousands; ranked by figures in Column 1).

Metro area of residence	Total labor force 16+ (1)	Percentage that are essential workers			
		Native-born (2)	Naturalized (3)	Legally resident noncitizens (4)	Undocumented (5)
US total	164,750	65%	67%	66%	74%
New York–Newark–Jersey City, NY–NJ–PA	10,400	59%	68%	66%	72%
Los Angeles–Long Beach–Anaheim, CA	6,990	57%	64%	65%	68%
Chicago–Naperville–Elgin, IL–IN–WI	5,045	62%	69%	66%	72%
Dallas–Fort Worth–Arlington, TX	3,945	63%	67%	62%	76%
Houston–The Woodlands–Sugar Land, TX	3,535	65%	68%	67%	77%
Washington–Arlington–Alexandria, DC–VA–MD–WV	3,515	58%	63%	63%	73%
Philadelphia–Camden–Wilmington, PA–NJ–DE–MD	3,210	64%	69%	62%	72%
Miami–Fort Lauderdale–West Palm Beach, FL	3,205	61%	66%	69%	74%
Atlanta–Sandy Springs–Roswell, GA	3,125	63%	63%	60%	74%
Boston–Cambridge–Newton, MA–NH	2,765	60%	70%	65%	68%
All other areas (including nonmetro)	119,010	66%	68%	66%	76%

Source: Center for Migration Studies. See text for data and methods.

metropolitan statistical areas (MSAs).⁶ For the United States overall, the naturalized and legally resident populations have about the same percentages of essential workers as native workers. In these MSAs, however, the percentages of undocumented and naturalized essential workers exceed that of the native-born by about 12 and 6 percent, respectively.

The foreign-born represent more than 50 percent of essential workers in the Miami–Fort Lauderdale–West Palm Beach and the San Jose–Sunnyvale–Santa Clara MSAs, and more than 40 percent in seven MSAs (Appendix, Table B).

Prior to the pandemic, the Trump administration set the lowest ceiling for US refugee admissions in the program’s 40-year history. Since then, the administration has virtually shut down the program, despite the immense achievements and contributions of refugees

to the country (Kerwin 2018). Table 3 shows that 70 percent of persons that entered the United States as refugees⁷ are essential workers. The percentages of refugee essential workers that live in rental housing, have incomes lower than the poverty level, and take public transportation surpass those of the native-born. A remarkable 78 percent of Black refugees are essential workers. Table C in the appendix sets forth the number and share of refugee essential workers by state.

The CARES Act provided tax rebates of up to \$1,200 for adults with incomes of less than \$99,000, up to \$2,400 for joint filers earning less than \$198,000, and

⁶Metropolitan Statistical Areas (MSAs), which are established by the Office of Management and Budget (OMB), must include at least one urbanized area “containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core” (US Census Bureau 2020).

⁷CMS derived the number of US residents who entered the country as refugees from 2018 American Community Survey (ACS) data as follows: (1) For each year from 1987 to 2018, DHS statistics were compiled for every country for (a) refugee arrivals, and (b) newly arriving lawful permanent residents (LPRs); (2) in each cell of the resulting matrix, the percentage of refugees to total arrivals was computed; (3) 2018 ACS data were compiled by country of origin and year of entry; and (4) in each cell of the matrix, the number residing in the United States in 2018 was multiplied by the percentage from (2), but only for those cells that had percentages of two-thirds or higher.

Table 3. Percentage of Refugees That Are Essential Workers Compared to Native-Born and Foreign-Born Workers (ages 16 and older): Selected Characteristics (in thousands).

Category	Refugees (1)	Native-Born (2)	Total Foreign-Born (3)
Total essential workers 16 and older	505	88,475	19,760
Median household income of essential workers	\$72,000	\$80,000	\$72,000
Percentage that are essential workers	70%	65%	69%
<i>Percentage that are essential workers — selected characteristics</i>			
Hispanic	73%	67%	75%
Black	78%	68%	73%
White	67%	64%	61%
Asian	70%	61%	62%
In rented housing	71%	65%	70%
No health insurance	70%	69%	77%
Below poverty level	67%	63%	67%
Use public transportation or carpool	71%	63%	70%

Source: Center for Migration Studies. See text for data and methods.

\$500 per child younger than 17 years old (DOT 2020). The rebate was reduced by \$5 for each additional \$100 of an adult's income that exceeded certain thresholds.⁸ As stated, the Act requires taxpayers to have filed their returns with a valid Social Security number. Both spouses filing a joint return must have used a valid Social Security number to secure a rebate. If not, the US citizen children in these families could not obtain the \$500 in relief.⁹ A US citizen with an undocumented spouse, however, could file an individual return and secure benefits for eligible household members. Combined, these requirements mostly excluded members of mixed-status families. In 2018, 18.3 million persons lived in 3.8 million mixed-status households (Kerwin et al. 2020).

Table 4 shows estimates of the number of essential workers (6.2 million) not eligible for payments under the CARES Act.¹⁰ In addition, a total of 3.8 million US citizen children (younger than age 17) of essential workers lived in households with at least one undocumented parent. The data show that these workers and families badly

need the financial support. Perhaps the most startling statistic in Table 4 is the 1.2 million US citizens younger than age 17 living in mixed-status households *below the poverty level*, most of whom did not qualify for relief.

Many immigrant essential workers face heightened risks. The 4.7 million without health insurance are in a particularly precarious position given the risk of contracting the virus at work. In addition, many of the 9.3 million living in rental units will be subject to eviction when short-term federal, state, and local moratoria on evictions expire (NHLP 2020; NLIHC 2020).

Table 5 shows that immigrant essential workers also must contend with a factor that puts them and their families at greater risk of contracting COVID-19: overcrowding. The percentage of immigrant essential workers that live in overcrowded households is almost three times higher for naturalized workers than for native-born workers. The percentage of legally resident essential workers in overcrowded households is more than four times that of native-born workers, and the percentage of undocumented essential workers in overcrowded households is more than six times that of the native-born. Conversely, the percentage of essential workers living in overcrowded households drops considerably from undocumented, to legally resident, to naturalized workers.¹¹

⁸The amount of the payment starts to phase out at \$75,000.

⁹The program pays only through the tax system and only if the tax filer qualifies.

¹⁰Because some US citizens and legal noncitizens, who are married to undocumented immigrants, do not file their taxes jointly, an unknown but likely small percentage of US citizens and legal noncitizens in mixed-status families is eligible for CARES Act payments.

¹¹Table 5 builds on earlier CMS work that demonstrates the benefits of immigrants advancing in legal status (Kerwin and Warren 2019).

Table 4. Essential Workers (and US citizen children) Not Eligible for CARES Payment Because of Their Immigration Status or the Immigration Status of a Household Member (numbers in thousands).

Category	Total essential workers not eligible (1)=(2)+(3)+(4)	US citizens 16 and older ^a (2)	Legal noncitizens, 16 and older ^{a,b} (3)	Unauthorized, 16 and older ^c (4)	US citizen children ^d (younger than age 17) of these workers (5)
Total population	6,174	450	442	5,283	3,830
Median household income ^e	\$50,000	\$60,500	\$53,870	\$50,200	\$45,000
Essential health care operations	414	55	38	321	N/A
Providers of basic necessities	49	6	5	38	N/A
Building cleaners or janitors	317	19	30	267	N/A
Disinfection	52	3	5	45	N/A
Male	4,200	277	304	3,619	1,955
Female	1,974	172	137	1,664	1,874
In rented housing	4,097	234	293	3,570	2,433
No health insurance	3,072	109	132	2,842	343
Below poverty level	903	54	82	767	1,241
Public transportation or carpool	1,605	77	103	1,425	N/A

N/A: Not applicable.

^aPersons married to undocumented immigrants that earn less than \$99,000 individually and less than \$198,000 jointly with their spouse.

^bIncludes both native-born and naturalized US citizens.

^cIncludes all undocumented immigrants that earn less than \$99,000 individually and less than \$198,000 jointly with their spouse.

^dIncludes all US citizen children with at least one undocumented parent whose parents make less than \$99,000 and less than \$198,000 jointly.

^eMedian household income in Column 5 refers to income in the households where these US citizen children live.

Data on immigrant essential workers by sector put into stark relief the contributions of immigrants to the nation's critical infrastructure and well-being during the pandemic. Immigrants comprise:

- 16 percent of US health care sector workers,¹² and 33 percent of health care sector workers in New York State, 32 percent in California, 31 percent in New Jersey, 28 percent in Florida, 25 percent in Nevada and Maryland, 24 percent in Hawaii, 23 percent in Massachusetts, and 19 percent in Texas.
- 26 percent of home health care workers and aides for the elderly.
- 22 percent of workers in scientific research and laboratories.

- 24 percent of workers in medical equipment manufacturing and 25 percent in pharmaceuticals manufacturing (i.e., businesses that supply the health care sector).
- 28 percent of janitors and building cleaners, 23 percent of workers in disinfection, and 23 percent of those who manufacture soap and cleaning compounds.¹³
- 26 percent of construction workers.
- 23 percent of US transportation industry workers, including buses, rails, water transport, and vehicles for hire, but excluding airlines.
- 28 percent of workers in telecommunications equipment manufacturing and 31 percent in computer and microelectronic manufacturing.
- 14 percent of workers in automobile and automobile parts manufacturing.

¹²A study by the New American Economy provides detailed estimates of immigrant health care workers, and highlights the immense demand for these workers in response to the pandemic (NEA 2020).

¹³This sector also includes cosmetic products.

Table 5. Percentage of Essential Workers (ages 16 and older) That Live in Overcrowded^a Households, by Legal Status and Selected Characteristics.

Category	Native-born (1)	Naturalized (2)	Legally resident noncitizens (3)	Undocumented (4)
Total population	3.8	10.3	17.7	23.5
Essential health care operations	3.1	8.0	12.6	15.4
Building cleaners or janitors	4.8	16.9	20.7	26.1
Disinfection	5.4	16.3	28.6	25.8
In rented housing	6.5	16.7	22.9	26.8
Below poverty level	9.5	20.5	30.6	35.0

^a“Overcrowded” defined by the Department of Housing and Urban Development (HUD) as an average of more than one person per room. Source: Center for Migration Studies. See text for data and methods.

- 21 percent of workers in warehousing, distribution, and fulfillment (i.e., who handle customer orders for e-commerce businesses).
- 31 percent of US agricultural employees.
- 26 percent of workers in food and beverage manufacturing and processing.
- 26 percent of grocery wholesalers, and 17 percent in retail grocery and other food and beverage stores (Appendix, Tables E and F).

The 10 essential industries that employ the highest numbers of naturalized citizens are hospitals (862,400 workers), restaurants (741,700), construction (701,600), transportation (571,300), building cleaners (345,400), government (330,200), banks (325,100), doctors’ and dentists’ offices (309,900), nursing homes (302,100), and real estate (255,900) (Appendix, Table F). Naturalized citizens make up 67 percent of the foreign-born working in health care, including 74 percent of those working in hospitals and 74 percent of those working in doctors’ and dentists’ offices (Appendix, Table D). Many of these essential workers are on the front lines with coronavirus patients.

Undocumented immigrants work — by essential industry — in construction (1,320,500), restaurants (846,100), agriculture and farms (310,800), landscaping (277,600), building cleaners (268,400), food processing and manufacturing (193,900), transportation (181,000), grocery stores (147,300), hotels and other accommodations (137,000), and warehousing, distribution, and fulfillment of online orders (103,000) (Appendix, Table F). Undocumented immigrants comprise 54 percent of foreign-born workers in agriculture and farms, 51 percent of foreign-born workers in construction, and 40 percent in disinfection (Appendix,

Table D). All of these workers will be vital to the ability of Americans and the US economy to rebound from the pandemic.

Table 6 shows the numbers of foreign-born essential workers, including the undocumented, in cities with large meatpacking or poultry-processing facilities. As discussed, the workers in these essential industries have been particularly hard hit by COVID-19.

III. Policy Recommendations

The COVID-19 pandemic has created the clearest, most compelling view to date of the indispensable contributions of immigrants to the nation’s well-being. Immigrants are working — often at great risk to their health and lives — to keep Americans safe, healthy, fed, and poised for economic recovery. Yet, paradoxically, large numbers also remain on the margins of US society. While nearly three-quarters of undocumented immigrants work in sectors officially deemed essential to the nation’s “critical infrastructure,” they can still lose their jobs,¹⁵ and be detained and deported. Foreign-born essential workers face a high risk of infection, but workplace protections have been relaxed during the pandemic. Several million have been denied federal aid and relief, and high numbers opt against seeking health care and benefits for fear that if they do, they or a family member will lose the ability to obtain permanent status under the public charge rule. The “essential” designation, however, also offers a kind of belated recognition

¹⁵The article’s essential worker figures are based on 2018 data; note, however, that the 2018 data would likely reflect the situation in the first half of 2020 because patterns of employment and legal status would not change appreciably in less than two years.

Table 6. Percentage of Noncitizen Essential Workers in Regions with Meatpacking or Poultry-Processing Facilities with High COVID-19 Infection Rates.¹⁴

Region	Total essential workers (1)	Noncitizen essential workers (2)	Percentage noncitizen essential workers (3)=(2)/(1)×100
Total, these 10 areas	517,200	41,000	7.9
Dodge City, Kansas	56,200	11,500	20.5
Green Bay, Wisconsin	37,000	5,300	14.3
Dakota City, Nebraska	73,400	6,500	8.9
Goodlettsville, Tennessee	40,800	3,600	8.7
Waterloo, Iowa	46,100	3,500	7.5
Worthington, Minnesota	43,800	3,000	6.8
Sioux Falls, South Dakota	72,100	3,500	4.9
St. Joseph, Missouri	41,600	1,800	4.3
Logansport, Indiana	47,900	1,700	3.5
Perry, Iowa	58,100	600	1.1

Source: Center for Migration Studies. See text for data and methods.

of their importance to the country, as well as a level of protection and kind of gray status that allow many undocumented persons to transit to and from work with less fear of deportation.

The pandemic — which will continue to ravage the nation and world in the near future — has exposed and exacerbated a range of social inequalities and injustices that need to be broadly addressed. This article offers a more modest proposal: that Congress and the president align US legal immigration policies with the manifest importance of these workers to the nation’s well-being. To that end, the administration should provide undocumented immigrant essential workers and, as necessary, their family members with temporary status, work authorization, and advanced parole for those who need to return home for a temporary period. The cases of essential workers in removal proceedings — who do not pose a legitimate public safety or national security risk — should be terminated. In addition, all essential workers should receive core protections and benefits from the society to which they are so generously contributing, often at risk of death, including COVID-19 relief payments and rigorously enforced labor and workplace safety standards. The administration should also withdraw the public charge rule in response to the hardship it has already caused to working-class persons, and the disincentive it creates during the pandemic to access public health benefits. In the longer term, Congress should pass legislation to create a path to permanent residence for US undocumented essential workers and their immediate family members.

IV. Methodology

To arrive at these estimates, CMS used the “essential critical infrastructure” categories set forth by DHS’s Cybersecurity and Infrastructure Security Agency (DHS-CISA 2020). DHS sets forth 17 categories of essential critical infrastructure workers. For simplicity and consistency with previous CMS reporting, CMS collapsed these 17 DHS categories into 14 categories that encompass all essential critical infrastructure workers. These 14 categories minimize overlap when matching US Census industry codes to DHS categories.¹⁶

CMS matched each essential category with a 2017 industry code by the Census Bureau. In the few cases when essential infrastructure categories did not correspond to Census Bureau industry codes, CMS matched categories to 2018 Census Bureau occupational codes.¹⁷ It then calculated the number of workers in each essential industry using 2018 1-year data from American Community Survey (ACS) data (in the Integrated Public

¹⁶In some cases, CMS consolidated the main categories shown in Appendix Table C to avoid showing small, statistically unreliable numbers. Within each category, the estimates were ranked on total foreign-born, and the smallest categories were summed and shown as other categories. With some exceptions, estimates smaller than a few thousand are not shown.

¹⁷These categories of essential businesses include corrections, electricians, plumbing, law enforcement, fire prevention and response, building inspection and code enforcement, security, emergency management and response, building cleaners and janitors, disinfection, and logistics.

Use Microdata Series [IPUMS]), weighted using individual weights calculated by the Census Bureau (Ruggles et al. 2020). CMS restricted the universe of employees to all individuals aged 16 and older.

Industry codes reflect the industries in which respondents to the ACS most recently performed their occupation. Likewise, occupation codes reflect most recent occupation. To restrict its estimates to individuals that were likely to be working in 2018, CMS included only individuals that were in the labor force at the time they responded to the ACS. Some individuals may work in more than one industry or occupation. For these individuals, the ACS records the industry or occupation in which they earned the most money.

Some industries (construction, restaurants, and hotels, for example) may include high numbers of workers in essential sectors who are not working during the

pandemic. Some workers may be furloughed or may have lost their jobs since 2018. These estimates should, thus, be regarded as an upper bound on the number of workers in essential infrastructure by their immigration status as of 2018.

CMS used both industry and occupational codes from the ACS to derive its estimates. Since industry codes encompass many occupations, CMS corrected its estimates for double count.

To estimate the number of naturalized citizens, legal noncitizens, and undocumented immigrants, CMS used information collected in the ACS. The annual series of CMS estimates of undocumented residents includes all the detailed characteristics collected in the ACS (Ruggles et al. 2020). A description of CMS estimation procedures and a discussion of the plausibility of the estimates are provided in Warren (2020).

Appendix

Table A. Foreign-Born Essential Workers by State and Legal Status: 2018.

State	Naturalized Citizens	Legal Foreign-Born	Undocumented	Foreign-Born Share of All Essential Workers (%)	Foreign-Born Share of Labor Force (%)
Total	9,609,000	4,619,600	5,531,300	18.3	17.5
Alabama	23,300	14,700	30,100	4.5	4.5
Alaska	20,500	6,800	2,700	11.4	10.6
Arizona	183,400	104,600	133,500	18.9	17.2
Arkansas	22,900	15,000	32,300	7.5	7.3
California	2,256,200	1,076,900	1,206,600	35.9	33.3
Colorado	108,400	61,300	84,600	12.9	12.0
Connecticut	116,400	54,300	58,200	18.7	18.4
Delaware	21,300	8,400	14,200	13.2	12.1
District of Columbia	16,600	14,600	10,900	18.6	16.7
Florida	1,020,500	474,900	396,300	28.2	26.6
Georgia	210,000	91,100	173,600	14.1	13.7
Hawaii	70,100	33,200	18,300	23.6	22.4
Idaho	21,500	10,700	26,000	10.2	8.6
Illinois	407,000	171,800	244,000	19.2	18.1
Indiana	63,200	37,500	52,500	6.7	6.8
Iowa	35,400	28,200	29,800	8.0	7.7
Kansas	41,600	18,200	39,700	9.8	9.5
Kentucky	32,600	19,100	26,500	5.5	5.2
Louisiana	28,900	15,400	35,100	5.5	5.5
Maine	11,000	7,400	2,400	4.3	4.0

(continued)

Table A. (continued)

State	Naturalized Citizens	Legal Foreign-Born	Undocumented	Foreign-Born Share of All Essential Workers (%)	Foreign-Born Share of Labor Force (%)
Maryland	237,400	90,500	118,300	21.2	20.1
Massachusetts	291,600	149,000	88,900	22.5	20.8
Michigan	155,400	72,400	55,400	8.4	8.2
Minnesota	118,800	61,600	48,700	11.4	10.7
Mississippi	10,500	6,600	11,200	3.2	3.2
Missouri	60,300	27,300	24,900	5.5	5.4
Montana	5,800	2,500	1,000	2.4	2.3
Nebraska	29,600	19,900	22,500	9.9	9.3
Nevada	127,000	51,400	84,900	27.4	25.5
New Hampshire	21,100	7,900	2,600	6.4	6.5
New Jersey	528,900	180,500	202,600	30.6	29.2
New Mexico	31,000	20,700	34,400	13.5	12.1
New York	1,100,300	480,700	360,800	31.0	28.2
North Carolina	136,100	80,500	158,600	11.2	10.9
North Dakota	7,100	6,000	5,200	6.0	6.3
Ohio	123,700	57,100	47,900	5.7	5.8
Oklahoma	41,900	24,900	48,100	9.0	8.1
Oregon	85,400	43,200	72,400	14.6	13.2
Pennsylvania	213,900	91,100	92,800	9.1	9.2
Rhode Island	34,000	11,500	12,100	16.4	16.2
South Carolina	45,400	26,600	40,000	6.8	6.6
South Dakota	9,900	4,900	2,100	5.2	4.7
Tennessee	64,000	41,200	66,900	7.7	7.1
Texas	820,800	515,200	918,500	24.0	22.4
Utah	44,800	32,000	49,800	12.9	11.2
Vermont	9,000	3,100	1,100	5.8	5.5
Virginia	244,100	92,400	144,200	17.1	16.8
Washington	232,500	116,600	148,800	19.7	18.8
West Virginia	4,900	800	2,300	1.5	1.7
Wisconsin	60,500	35,800	43,300	6.7	6.3
Wyoming	2,600	1,800	3,500	3.6	3.9

Table B. Foreign-Born Shares of Essential Workers by Metro Area.

Rank	Metro Area	Foreign-Born Share of Essential Workers (%)
1	Miami–Fort Lauderdale–West Palm Beach, Florida	53.0
2	San Jose–Sunnyvale–Santa Clara, California	50.3
3	Merced, California	47.0
4	Salinas, California	45.5
5	Los Angeles–Long Beach–Anaheim, California	42.8
6	El Centro, California	41.0
7	New York–Newark–Jersey City, New York–New Jersey–Pennsylvania	40.1
8	McAllen–Edinburg–Mission, Texas	39.8
9	San Francisco–Oakland–Hayward, California	39.7
10	Naples–Immokalee–Marco Island, Florida	38.1

(continued)

Table B. (continued)

Rank	Metro Area	Foreign-Born Share of Essential Workers (%)
11	Madera, California	37.4
12	Visalia–Porterville, California	37.4
13	Stockton–Lodi, California	36.9
14	Yuma, Arizona	36.7
15	Yakima, Washington	35.3
16	Santa Maria–Santa Barbara, California	34.6
17	Napa, California	34.0
18	Brownsville–Harlingen, Texas	33.9
19	Laredo, Texas	33.7
20	Houston–The Woodlands–Sugar Land, Texas	32.5
21	Bakersfield, California	32.4
22	Washington–Arlington–Alexandria, DC–Virginia–Maryland– West Virginia	32.4
23	Fresno, California	32.3
24	Las Vegas–Henderson–Paradise, Nevada	31.2
25	Oxnard–Thousand Oaks–Ventura, California	31.0

Table C. Refugee Essential Workers by State.

State	Number of Refugee Essential Workers, 2018	Share of Essential Workers among Refugees in the Labor Force (%)
Total	504,900	70.1
California	72,800	65.8
New York	48,300	68.9
Minnesota	41,900	77.4
Texas	32,400	68.5
Florida	27,100	73.7
Washington	24,900	70.3
Ohio	23,600	71.9
Michigan	22,900	76.9
Illinois	20,000	66.5
Pennsylvania	14,000	72.1
Georgia	13,100	70.1
New Jersey	13,000	62.0
Wisconsin	12,200	82.3
Arizona	10,900	79.2
Virginia	10,700	61.8
Missouri	9,700	65.1
Massachusetts	9,200	62.7
Iowa	8,800	83.9
Maryland	8,200	61.0
Colorado	7,300	67.3
North Carolina	7,100	61.9
Tennessee	6,600	72.5
Nebraska	5,800	86.6
Oregon	5,700	60.5

Table C. (continued)

State	Number of Refugee Essential Workers, 2018	Share of Essential Workers among Refugees in the Labor Force (%)
Kentucky	5,000	84.2
Utah	4,800	74.6
South Dakota	4,700	97.7
Connecticut	4,400	73.6
Indiana	3,500	53.0
Maine	3,000	90.2
North Dakota	2,700	67.5
Nevada	2,400	48.9
Oklahoma	2,200	88.3
Rhode Island	2,000	81.2
Kansas	2,000	75.7
South Carolina	1,700	66.5
Idaho	1,500	82.2
Montana	1,400	100.0
New Hampshire	1,300	61.3
Vermont	1,200	77.2
Alaska	<1,000	57.8
Arkansas	<1,000	62.9
Mississippi	<1,000	91.9
Delaware	<1,000	79.5
Alabama	<1,000	77.4
Louisiana	<1,000	48.3
District of Columbia	<1,000	45.0
Hawaii	<1,000	76.0
New Mexico	<1,000	60.4

(continued)

Table D. Foreign-Born Essential Workers by Select Industries and Immigration Status.

	Foreign-Born Essential Workers	Naturalized Share of All Foreign-Born Essential Workers (%)	Legal Noncitizen Share of All Foreign-Born Essential Workers (%)	Undocumented Share of All Foreign-Born Essential Workers (%)
Total	19,759,900	48.6	23.4	28.0
Total Essential Health Care Operations	3,013,500	67.3	21.1	11.7
Research and laboratory services	149,800	52.4	31.1	16.5
Hospitals	1,169,200	73.8	18.1	8.1
Walk-in care health facilities	232,300	67.1	19.0	13.9
Medical wholesale and distribution	39,000	54.9	28.9	16.2
Home health care workers or aides for the elderly	392,600	56.0	27.5	16.4
Offices of doctors and emergency dentists	416,800	74.4	16.5	9.2
Nursing homes or residential health care facilities or congregate care facilities	496,700	60.8	23.3	15.9
Other Essential Industries				
Transportation infrastructure such as bus, rail, for-hire vehicles, and garages	990,400	57.7	24.0	18.3
Food processing, manufacturing agents, including all foods and beverages	538,700	37.0	27.0	36.0
Medical equipment and instruments	152,300	64.0	20.3	15.8
Pharmaceuticals manufacturing	135,500	63.7	22.6	13.7
Manufacture of soap and cleaning compounds	33,900	44.4	33.3	22.3
Telecommunications manufacturing	36,500	64.6	23.4	12.0
Microelectronics, semiconductors manufacturing	310,000	60.1	22.4	17.6
Agriculture and farms	579,400	18.8	27.6	53.6
Tire manufacturing	8,600	34.1	25.1	40.8
Cement, concrete, lime, and gypsum product manufacturing	24,500	37.8	23.9	38.3
Rubber products (except tires) manufacturing	8,900	32.2	23.9	43.9
Household appliance manufacturing	9,500	31.5	28.1	40.5
Motor vehicles and motor vehicle equipment manufacturing	197,400	43.5	32.5	23.9
Grocery and related product merchant wholesalers	214,000	37.9	26.4	35.6
Grocery stores, including all food and beverage stores	518,100	45.2	26.4	28.4
Warehouse, distribution, and fulfillment	321,900	39.0	29.0	32.0
Construction	2,578,000	27.2	21.6	51.2
Electricians	127,200	48.8	21.8	29.5
Plumbers	97,200	37.2	21.1	41.7
Building cleaners or janitors	861,000	40.1	28.7	31.2
Disinfection	113,800	28.3	32.1	39.6

Table E. Foreign-Born Essential Workers by Select States and Industries.

	California	Florida	Hawaii	Illinois	Maryland	Mass.	Michigan	Nevada	New Jersey	New York	Penn.	Texas
Number of:												
Health care workers	597,700	313,900	16,700	122,900	100,000	124,100	50,200	30,700	168,300	409,000	82,200	260,600
Janitors and building cleaners	173,000	86,900	5,000	36,400	17,900	24,200	5,200	16,100	36,600	100,300	17,500	105,600
Workers in disinfection	33,100	12,300	1,400	2,800	700	3,400	1,000	2,500	3,200	7,500	2,000	15,100
Workers in agriculture	291,093	35,346	2,540	3,982	1,010	1,096	5,330	1,237	3,675	6,454	7,334	32,198
Workers in food and beverage manufacturing	112,800	22,800	1,700	29,600	3,100	10,200	9,400	3,300	20,300	21,900	16,600	44,600
Workers in transport (except airlines)	225,700	111,500	5,900	60,400	18,300	22,000	12,900	13,300	51,500	159,200	18,600	100,100
Percentage of All:												
Health care workers	31.6	27.7	24.2	16.7	24.6	23.3	8.2	24.8	30.7	32.9	9.2	18.6
Janitors and building cleaners	52.4	41.9	31.6	28.7	32.2	39.1	4.9	51.2	46.9	40.8	13.7	41.1
Workers in disinfection	53.7	30.5	39.2	16.8	12.7	36.2	5.9	47.3	38.6	32.7	12.8	31.6
Workers in agriculture	68.4	48.2	35.1	7.3	8.6	10.9	12.9	19.2	32.1	15.6	14.9	30.0
Workers in food and beverage manufacturing	44.1	37.7	32.6	27.0	15.5	38.5	19.8	35.7	45.5	29.6	18.5	33.6
Workers in transport (except airlines)	42.5	38.1	31.8	25.9	22.9	30.8	12.3	27.7	36.7	47.1	10.3	25.3

Table F. Foreign-Born Essential Workers in the United States, by Legal Status and Sector: 2018.

Type of worker or economic activity	Legal status of foreign-born			Foreign-born share of essential workers (%)
	Naturalized	Legally resident	Undocumented	
Total foreign-born essential workers	9,609,000	4,619,600	5,531,300	18.3
Essential Health Care Operations	2,026,900	635,000	351,600	16.3
Hospitals	862,400	212,000	94,800	16.1
Nursing homes or residential health care facilities or congregate care facilities	302,100	115,700	78,900	16.9
Offices of doctors and emergency dentists	309,900	68,600	38,200	14.8
Home health care workers or aides for the elderly	220,000	108,000	64,600	25.7
Walk-in care health facilities	155,900	44,000	32,400	12.8
Research and laboratory services	78,400	46,600	24,800	22.2
Medical wholesale and distribution	21,400	11,300	6,300	16.2
Emergency veterinary and livestock services	10,500	5,800	2,800	5.1
Other essential health care operations	66,400	22,800	8,800	11.1
Essential Infrastructure	1,045,800	424,700	376,200	21.1
Transportation infrastructure such as bus, rail, for-hire vehicles, and garages	571,300	238,000	181,000	22.8
Hotels and places of accommodation	238,400	105,200	137,000	30.7
Telecommunications and data centers	90,800	36,200	31,400	15.1
Airports and airlines	77,500	25,800	15,800	18.8
Utilities, including power generation, fuel supply, and transmission	47,200	14,000	9,500	8.5
Public water and wastewater	20,600	5,500	1,500	8.6
Essential Manufacturing	1,198,800	699,400	857,000	20.8
Agriculture and farms	108,800	159,900	310,800	31.3
Food processing, manufacturing agents, including all foods and beverages	199,200	145,500	193,900	26.4
Microelectronics, semiconductors	186,200	69,300	54,500	30.5
Motor vehicles and motor vehicle equipment manufacturing	86,000	64,200	47,200	13.6
Medical equipment and instruments	97,400	30,900	24,000	24.2
Pharmaceuticals	86,400	30,600	18,500	25.2
Aircraft and parts manufacturing	83,400	20,800	13,100	16.7
Plastics product manufacturing	35,300	19,600	23,900	17.5
Electric lighting and electrical equipment manufacturing, and other electrical component manufacturing, national electric code	42,700	16,000	14,600	20.0
Miscellaneous fabricated metal products manufacturing	24,800	14,500	15,100	15.6
Chemicals	26,800	13,800	12,100	12.1
Structural metals, and boiler, tank, and shipping container manufacturing	22,900	12,000	17,400	13.9
Household paper products	24,700	10,300	13,200	12.7
Machine shops; turned product; screw, nut, and bolt manufacturing	22,300	11,000	12,800	14.1
Telecommunications	23,600	8,500	4,400	28.0
Sanitary products	15,000	11,300	7,600	23.2
Iron and steel mills and steel product manufacturing	15,200	7,300	10,700	11.9
Other essential manufacturing	98,200	53,900	63,000	12.1

(continued)

Table F. (continued)

Type of worker or economic activity	Legal status of foreign-born			Foreign-born share of essential workers (%)
	Naturalized	Legally resident	Undocumented	
Essential Wholesale	203,300	112,600	137,200	17.6
Grocery and related product merchant wholesalers	81,200	56,600	76,300	26.0
Household appliances and electrical and electronic goods merchant wholesalers	21,500	11,100	7,700	18.4
Machinery, equipment, and supplies merchant wholesalers	21,800	7,900	9,900	9.3
Motor vehicle and motor vehicle parts and supplies merchant wholesalers	21,200	9,800	8,100	16.2
Lumber and other construction materials merchant wholesalers	11,400	4,100	9,000	14.5
Hardware, and plumbing and heating, equipment and supplies merchant wholesalers	10,500	5,200	3,900	11.0
Petroleum and petroleum products merchant wholesalers	5,800	3,800	2,500	12.2
Paper and paper products merchant wholesalers	4,600	1,600	2,700	15.2
Other essential wholesale	25,400	12,500	17,100	15.3
Energy	53,900	31,800	30,500	12.5
Support activities for mining	25,600	19,100	18,100	14.2
Petroleum refining	11,700	5,400	5,500	13.8
Oil and gas extraction	8,400	4,500	3,400	12.6
Other energy workers	8,100	2,700	3,500	7.5
Essential Retail	1,228,100	745,400	1,085,200	18.4
Restaurants	741,700	516,800	846,100	20.5
Grocery stores, including all food and beverage stores	234,000	136,800	147,300	16.7
Pharmacies	100,100	29,100	20,500	16.1
Hardware and building material stores	64,200	28,300	28,900	9.3
Gas stations	56,000	22,900	26,500	18.0
Convenience stores	28,900	10,200	13,900	15.8
Fuel dealers	3,300	1,300	2,200	7.3
Essential Services	761,200	461,700	661,100	20.2
Landscapers	109,900	112,200	277,600	35.3
Warehouse, distribution, and fulfillment	125,500	93,400	103,000	21.1
Auto repair	130,600	73,000	102,200	17.0
Child care services	144,600	80,500	66,700	18.0
Mail and shipping services	139,000	44,700	26,800	13.5
Laundromats	42,600	21,500	42,800	37.9
Trash and recycling collection, processing, and disposal	33,900	16,400	25,700	15.8
Personal and household goods repair	17,400	11,300	8,000	21.1
Animal shelters	12,000	5,700	6,900	7.7
Funeral homes, crematoriums, and cemeteries	6,000	3,100	1,500	7.1
News Media	46,700	20,600	16,600	12.2
Financial Institutions	1,020,900	337,100	229,300	14.4
Banks	325,100	111,900	85,000	15.8
Real estate	255,900	66,000	51,800	14.6
Services related to financial markets	166,100	65,300	41,600	14.2
Insurance	154,400	48,900	37,800	11.8
Payroll and accounting	119,400	45,000	13,000	15.0

(continued)

Table F. (continued)

Type of worker or economic activity	Legal status of foreign-born			Foreign-born share of essential workers (%)
	Naturalized	Legally resident	Undocumented	
Providers of Basic Necessities to Economically Disadvantaged Populations and Employees at Correctional Facilities	223,300	81,700	38,600	14.8
Services to individuals and families	186,000	70,700	35,500	17.8
Food banks and shelters	11,000	4,500	2,600	11.7
Other providers of basic necessities	26,300	6,600	400	6.4
Construction	799,800	604,100	1,398,500	24.8
Construction	701,600	555,900	1,320,500	26.0
Electricians	62,000	27,700	37,500	15.1
Plumbers	36,200	20,500	40,500	17.2
Defense	103,700	38,500	0	9.0
Essential Services Necessary to Maintain the Safety, Sanitation, and Essential Operations of Residences or Other Essential Businesses	539,600	336,800	342,200	19.1
Building cleaners or janitors	345,400	247,300	268,400	27.9
Security	80,400	33,700	24,700	13.5
Disinfection	32,200	36,500	45,100	23.2
Emergency management and response	9,700	2,800	3,100	5.8
Other essential services necessary to maintain safety, sanitation, and essential operations	71,900	16,500	900	5.9
Vendors That Provide Essential Services or Products, Including Logistics and Technology Support	357,100	90,200	7,300	9.8

Source: Center for Migration Studies. See text for method of estimation.

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