

Occupations by Proximity and Indoor/Outdoor Work: Relevance to COVID-19 in All Workers and Black/Hispanic Workers



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Introduction: This paper describes the occupations in the U.S. that involve close contact with others and whether the work is outdoors or indoors (risk factors for COVID-19), including the distribution of Black and Hispanic workers over these occupations.

Methods: U.S. data released from 2014 to 2019 on employment, proximity to others at work, outdoor or indoor work, and Black and Hispanic worker percentages for occupations were used. Occupations were assigned to 6 categories defined as a low, medium, or high physical closeness (proximity) at work and outdoor or indoor work. A total of 3 of the 6 categories represent a higher risk for exposure to SARS-CoV-2: medium-proximity indoor, high-proximity outdoor, and high-proximity indoor exposure.

Results: A high proportion of U.S. workers may be at higher risk for exposure to SARS-CoV-2 because their occupations involve either high proximity to others indoors and outdoors (25.2%, 36.5 million workers) or medium-proximity indoors (48%, 69.6 million workers). There is a differential distribution of proximity and outdoor/indoor work by occupation, which disproportionately affects Black and Hispanic workers in some occupations.

Conclusions: Implementation of COVID-19 preventive measures in work settings should be based on occupation-specific risk factors, including the extent of proximity to others and whether the work is conducted outdoors or indoors. It is important that communication messages are tailored to the languages and preferred media of the workforce.

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INTRODUCTION

Researchers have used national data to identify occupations that are likely at higher risk of coronavirus disease 2019 (COVID-19) because workers are physically close to others, exposed to disease/infection, or some combination of these. Baker and colleagues¹ combined data on employment from the U.S. Bureau of Labor Statistics (BLS) with answers to questions that are available from the Occupational Information Network (O*NET).² They used answers to a question about having a job that required exposure to diseases or infections from surveys conducted before 2020. Another study identified occupations that scored high for both exposure to diseases and working physically close to others.³ The criteria for working physically

close to others was from arm's length to near touching. Although there is general agreement that the risk of transmission increases with decreasing distance from an infected person, the risk is still present beyond arm's length, and some level of risk is present beyond the 6-foot separation commonly recommended to prevent transmission. The 6-foot recommendation is based on

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past evidence focused on large droplets. More recent research suggests that sneezing, coughing, exercise-related heavy respiration, singing, and speaking can generate droplets of all sizes, including small ones that may travel well beyond 6 feet and remain suspended in the air for hours.^{4–9}

A nonpeer reviewed economics discussion paper and a newspaper article used data from O*NET to examine both disease risk and proximity at work along continuums of scores from 0 to 100.^{10,11} The economics discussion paper noted that many healthcare jobs had higher ratings on both scales. However, they neither described the full range of medium- to high-proximity occupations nor provided employment numbers for these groups of occupations.

Ventilation can also influence the risk of transmission. A prepeer reviewed study suggested that the transmission of COVID-19 is increased greatly in closed environments versus the transmission in open-air settings (H Nishiura, unpublished data, April, 2020). A recommendation for minimizing airborne transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) indoors includes adjusting ventilation systems to increase outdoor air exchange rates and minimize recirculation.¹² From a proposed multifactorial scheme to estimate the risk of SARS-CoV-2 transmission from asymptomatic people, the risk is judged as increasing across 3 ventilation categories: outdoors and well ventilated, indoors and well ventilated, and poorly ventilated.⁵ However, outdoor work still poses a risk if workers are in close contact with others. O*NET questionnaire data include responses to questions about the frequency of working outdoors, in addition to responses to the question about physical proximity to others at work that allows a cut off point greater than arm's length.

Black and Hispanic minorities have experienced a higher risk for COVID-19 and severe illness.^{13,14} The Centers for Disease Control and Prevention indicates that factors contributing to this increased risk experienced by racial and ethnic minority populations include discrimination; housing; healthcare access and utilization; educational, income, and wealth gaps; and occupation.¹⁵ It is important to identify occupations that may pose a risk for COVID-19 because of working close to others and indoors where ventilation may be inadequate and to identify in which of these occupations Black and Hispanic workers are over-represented. Such data could be used to guide workplace mitigation strategies to reduce exposure risk to SARS-CoV-2.

Publicly available data from O*NET and BLS were used to address the following questions:

1. How many U.S. workers are in the 6 categories defined by classifying all occupations as low, medium, or high physical closeness (proximity) at work and outdoor or indoor work?
2. What is the distribution of workers in the 3 higher-risk categories of medium- and high-proximity indoors and high-proximity outdoors for the major Standard Occupational Classification (SOC) occupations?
3. In which occupations in the higher-risk work categories are Black/African American and Hispanic/Latinx workers over-represented?

METHODS

Study Sample

This study combined the U.S. national employment numbers, data on Black/African American and Hispanic/Latinx workers, and work physical proximity and outdoor work information. National employment numbers came from BLS May 2019 Occupational Employment Statistics (OES) data release.¹⁶ The Employed Labor Force query system maintained by the National Institute for Occupational Safety and Health Division of Safety Research was used for 5-year (2014–2018) Current Population Survey employment numbers for all workers and Black and Hispanic workers.¹⁷ These were used to calculate the percentages of Black and Hispanic workers in occupations.

Measures

Information on physical proximity and outdoor work came from the O*NET database released in May 2020, which contains data from 2002 to 2019.² Data from the O*NET Work Context module was used for the question: *How physically close to other people are you when you perform your current job?* The response options were as follows: *I don't work near other people* (beyond 100 feet), *I work with others but not closely* (e.g., private office), *slightly close* (e.g., shared office), *moderately close* (at arm's length), and *very close* (near touching). Data from 2 questions on outdoor work were also used: *How often does your current job require you to work outdoors, exposed to all weather conditions?* *How often does your current job require you to work outdoors, under cover (like in an open shed)?* The response options for these questions were as follows: *never*, *once a year or more but not every month*, *once a month or more but not every week*, *once a week or more but not every day*, and *every day*.

O*NET reports average standardized scores for each detailed occupational group, resulting in scores ranging from 0 to 100. The average scores were used to create 3 categories for physical proximity: low=average score <50 (not close to further than slightly close), medium=average score between 50 and 75 (slightly close to further than an arm's length), and high=average score ≥75 (at arm's length or closer). A total of 2 categories were created from the outdoor work questions at average scores <75 and ≥75 (once a week or more but not every day to every day). If either of the outdoor work questions had an average score ≥75, the occupation was coded as outdoor work, and if neither had a score ≥75, the occupation was coded as indoor work.

The 2010 SOC system uses a 6-digit code. The detailed occupation is represented by the sixth digit, and the broad occupation group is represented by the fourth and fifth digits. To combine

the O*NET data and the BLS national employment data, their codes were crosswalked to 2010 SOC codes at the detailed occupation level.¹⁸ When an OES employment number was for a broad group SOC code, it was equally divided between the detailed occupation SOC codes within the broad group.

A crosswalk was used to link the 2010 Census codes used by the Current Population Survey to the 2010 SOC codes.¹⁹ When the percentages of Black and Hispanic workers in the occupational groups were given for a broad SOC code, these percentages were assigned to each of the detailed SOC codes inside that broad category. For this analysis, people of Hispanic or Latinx ethnicity could be of any race. The employment numbers for Black and Hispanic workers were calculated by multiplying the OES employment numbers by the Current Population Survey percentages of these workers. Over-representation by Hispanic and Black workers was defined as a third or more increased percentage in an occupation.

Statistical Analysis

The generated data were used for the descriptive summaries presented in the text, figure, and tables. JMP, version 15, was used for data management and analysis.

RESULTS

There was information on 772 detailed occupations and 144,525,052 workers after the combination. Nearly half of U.S. workers (48.1%) were in medium-proximity indoor jobs (Table 1), followed by high proximity indoor jobs (22.1%). High-proximity outdoor occupations only made up 3.1% of the workforce.

Details on employment numbers and percentages for the major SOC groups by the 6 proximity and outdoor/indoor work categories are presented in Appendix Table 1 (available online). Focusing on the 3 categories of higher risk for exposure, sales and related (14,453,660) and office and administrative support (13,060,230) had

the largest number of workers in the medium-proximity indoor category, followed by food preparation and serving related (6,734,840) and production (6,888,605) (Figure 1). The high-proximity indoor category had the largest number of workers in healthcare practitioners and technical (7,590,064), followed by food preparation and serving related (6,667,700); healthcare support (4,885,250); education, training, and library (4,500,990); and personal care and service (3,897,410). The high-proximity outdoor category had the largest number of workers in construction and extraction (1,485,220), followed by protective service (1,207,650) and building and grounds cleaning and maintenance (912,660).

Comparing the distribution of Black workers with that of all workers, the high-proximity indoor work category was somewhat higher at 27.5% vs 22.1% (Table 1). By contrast, Hispanic workers had higher representation in outdoor work categories: 5.0% of Hispanic versus 3.1% of all workers in the high-proximity outdoor work category and 7.0% versus 5.3% in the medium-proximity outdoor category.

Of the 144,525,052 workers in the data set, Black workers represented 13.0%, and Hispanic workers represented 17.1%. Thus, over-representation was $\geq 17.3\%$ for Black workers and $\geq 22.8\%$ for Hispanic workers. Black workers were over-represented in 103 (13.3%) of the 772 detailed occupations, and this represented 7,280,201 (38.9%) of Black workers in the data set. For Black workers, 80 of the 103 over-represented detailed occupations were in the proximity and outdoor/indoor categories at higher risk for exposure. These 80 occupations represented 6,494,471 Black workers (34.7% of the total number). Hispanic workers were over-represented in 124 (16.1%) of the 772 detailed occupations, representing 7,996,925 (32.3%) of Hispanic workers in the data set.

Table 1. Employment in 6 Categories of Proximity and Outdoor/Indoor Work for All, Black, and Hispanic Workers

Proximity and outdoor/indoor work category	Number of occupations (detailed SOC codes)	All workers employment numbers (% of total employment)	Black employment numbers (% of Black employment)	Hispanic employment numbers (% of Hispanic employment)
Low-proximity outdoor	29	2,279,010 (1.6)	246,387 (1.3)	504,531 (2.0)
Low-proximity indoor	192	28,461,032 (19.7)	2,850,110 (15.2)	3,978,773 (16.1)
Medium-proximity outdoor	75	7,666,365 (5.3)	814,610 (4.3)	1,741,626 (7.0)
Medium-proximity indoor	306	69,580,291 (48.1)	9,230,370 (49.3)	12,238,575 (49.5)
High-proximity outdoor	34	4,541,990 (3.1)	445,029 (2.4)	1,240,760 (5.0)
High-proximity indoor	136	31,996,364 (22.1)	5,151,916 (27.5)	5,033,377 (20.3)
Total	772	144,525,052	18,738,422 (13.0) ^a	24,737,642 (17.1) ^a

^aValues are presented as the percentage of Black and Hispanic workers in the workforce. SOC, Standard Occupational Classification.

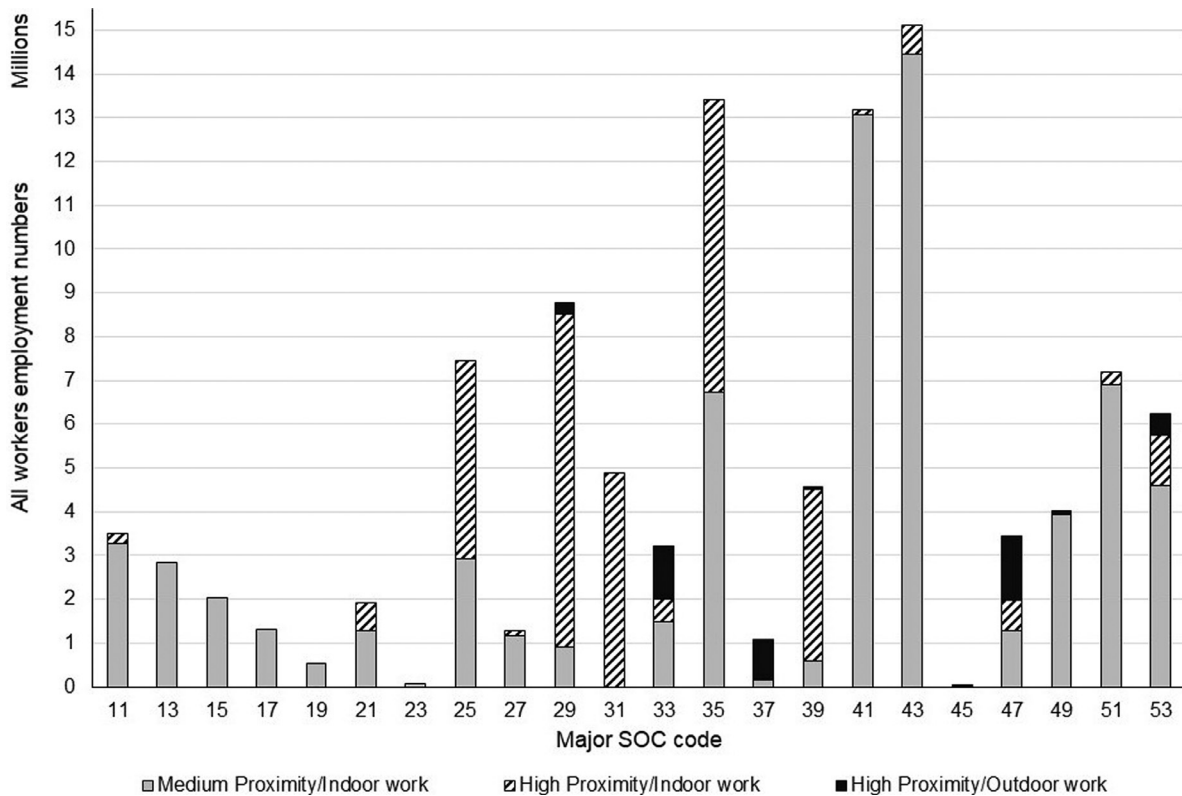


Figure 1. Employment numbers for the 3 categories of medium- and high-proximity indoor work and high-proximity outdoor work for the 22 major SOC occupations.

Note: A total of 11 management; 13 business and financial operations; 15 computer and mathematical; 17 architecture and engineering; 19 life, physical, and social science; 21 community and social service; 23 legal; 25 education, training, and library; 27 arts, design, entertainment, sports, and media; 29 healthcare practitioners and technical; 31 healthcare support; 33 protective services; 35 food preparation and serving related; 37 building and grounds cleaning and maintenance; 39 personal care and service; 41 sales and related; 43 office and administrative support; 45 farming, fishing, and forestry; 47 construction and extraction; 49 installation, maintenance, and repair; 51 production; and 53 transportation and material moving.

SOC, Standard Occupational Classification.

For Hispanic workers, 76 of the 124 over-represented occupations were in the higher-risk categories. These 76 occupations represented 5,306,726 Hispanic workers (21.5% of the total number).

Within the 3 higher-risk work categories, Black and Hispanic workers were over-represented in some of the same major occupational groups (Table 2). For example, common to both were healthcare support, personal care and service, transportation and material moving, food preparation and service related, production, and office and administrative support. Contrasts between Black and Hispanic workers included over-representation by Black workers in healthcare practitioners and technical, community and social service, and protective service compared with over-representation by Hispanic workers in construction and extraction; building and grounds cleaning and maintenance; and installation, maintenance, and repair.

The 80 detailed occupations with a higher risk for exposure in which Black workers were over-represented are

listed in Appendix Table 2 (available online), separated into the 3 higher-risk proximity and outdoor/indoor work categories. A comparable listing of the 76 detailed occupations for Hispanic workers appears in Appendix Table 3 (available online). The 3 occupations with the most workers in each of the higher-risk categories were extracted separately for Black and Hispanic workers (Table 3). In the high-proximity indoor work category, these occupations for Black workers were home health aides, nursing assistants, and personal care aides. By contrast, the comparable occupations for Hispanic workers were cooking and restaurant, medical assistants, and dining room and cafeteria attendants and bartender helpers. The category of high-proximity outdoor work was distinctive by having many fewer Black than Hispanic workers in their respective 3 most-populous detailed occupations, with approximately 36,000 vs 750,000 workers, respectively. The top Hispanic occupation in this category was landscaping and groundskeeping workers with almost 400,000 workers, followed

Table 2. Black and Hispanic Worker Employment in Occupations Where They Are Over-represented

Proximity and outdoor/indoor work category	Black workers employment (number of occupations)	Black workers, major SOC group	Hispanic workers employment (number of occupations)	Hispanic workers, major SOC group
High-proximity indoor	1,188,752 (7)	Healthcare support	631,486 (2)	Food preparation and serving related
	418,414 (3)	Personal care and service	282,684 (2)	Healthcare support
	255,916 (4)	Transportation and material moving	100,894 (2)	Production
	243,929 (1)	Food preparation and serving related	16,689 (1)	Farming, fishing, and forestry
	228,574 (4)	Healthcare practitioners and technical	4,627 (1)	Personal care and service
	140,438 (3)	Community and social service	889 (1)	Construction and extraction
	130,761 (4)	Protective service		
	63,559 (3)	Production		
	52,841 (3)	Office and administrative support		
	34,374 (1)	Sales and related		
High-proximity outdoor	23,068 (2)	Protective service	505,962 (9)	Construction and extraction
	9,709 (1)	Personal care and service	399,745 (1)	Building and grounds cleaning and maintenance
	4,324 (1)	Installation, maintenance, and repair	11,300 (1)	Personal care and service
	2,638 (1)	Transportation and material moving	2,205 (2)	Installation, maintenance, and repair
Medium-proximity indoor	780,452 (4)	Transportation and material moving	1,124,849 (4)	Transportation and material moving
	643,990 (2)	Sales and related	793,400 (5)	Food preparation and serving related
	630,042 (5)	Food preparation and serving related	633,946 (21)	production
	529,202 (7)	Office and administrative support	420,534 (14)	Construction and extraction
	392,292 (7)	Production	274,294 (6)	Installation, maintenance, and repair
	353,850 (2)	Protective service	39,510 (1)	Building and grounds cleaning and maintenance
	255,654 (8)	Community and social service	32,569 (1)	Office and administrative support
	57,054 (2)	Healthcare practitioners and technical	19,309 (1)	Arts, design, entertainment, sports, and media
	37,365 (2)	Personal care and service	11,834 (1)	Personal care and service
	14,524 (1)	Business and financial operations		

Note: Over-representation by Hispanic and Black workers was defined as a third or more higher % in an occupation. Of the 144,525,052 workers in the data set, Black workers represented 13.0%, and Hispanic workers represented 17.1%. Thus, over-representation was $\geq 17.3\%$ for Black workers and $\geq 22.8\%$ for Hispanic workers.
SOC, Standard Occupational Classification.

by carpenters and the combination of cement masons and concrete finishers. Finally, for medium-proximity indoor work, laborers and freight, stock, material movers, and hand workers included large numbers of both Black and

Hispanic workers. The other 2 occupations were cashiers and the combination of stock clerks and order fillers for Black workers versus packers and packagers, hand workers, and food preparation workers for Hispanic workers.

Table 3. The 3 Most-Populous Detailed Occupations in Which Black and Hispanic Workers Are Over-represented

Black workersdetailed occupation (n workers)Major occupation group	Hispanic workersdetailed occupation (n workers) Major occupation group
High-proximity indoor	
Home health aides (570,651) Healthcare support	Cooks, restaurant (489,260) Food preparation and serving related
Nursing assistants (512,591) Healthcare support	Medical Assistants (192,356) Healthcare support
Personal care aides (382,542) Personal care and service	Dining Room and cafeteria attendants and bartender helpers (142,226) Food preparation and serving related
High-proximity outdoor	
Crossing guards (21,824) Protective service	Landscaping and groundskeeping workers (399,745) Building and grounds cleaning and maintenance
Baggage porters and bellhops (9,709) Personal care and service	Carpenters (254,023) Construction and extraction
Riggers (4,324) Installation, maintenance, and repair	Cement masons and concrete finishers (94,138) Construction and extraction
Medium-proximity indoor	
Cashiers (640,200) Sales and related	Laborers and freight, stock, material movers, and hand workers (682,182) Transportation and material moving
Laborers and freight, stock, material movers, and hand workers (552,243) Transportation and material moving	Packers and packagers and hand workers (264,862) Transportation and material moving
Stock clerks and order fillers (388,725) Office and administrative support	Food preparation workers (236,665) Food preparation and serving related

Note: Over-representation by Hispanic and Black workers was defined as a third or more higher percentage in an occupation. Of the 144,525,052 workers in our data set, Black workers represented 13.0%, and Hispanic workers represented 17.1%. Thus, over-representation was $\geq 17.3\%$ for Black workers and $\geq 22.8\%$ for Hispanic workers.

DISCUSSION

Using pre-COVID-19 data, about 32 million (22%) U.S. workers were in occupations where they had high proximity to others and worked indoors. Another 4.5 million workers (3%) worked in high proximity to others but were outdoor workers. The largest single group of workers or 69.6 million (48%) was in occupations that involved medium proximity to others and indoor work. The cut point of 6 feet as a physical distance from others while at work cannot be matched by the scale used by O*NET for the question, but certainly, the high proximity is within the 6 feet recommendation, and some percentage of workers meeting the medium proximity definition will be within the 6 feet distance from others while working.

Being outdoors has been described as having less risk for transmission of COVID-19 than being in a closed environment (H Nishiura, unpublished data, April, 2020). However, the risk of transmission outdoors is also affected by how close people are to each other, and high proximity increases the risk.

Although there are recommendations for keeping a distance of at least 6 feet between people, such social distancing may not be possible in both indoor and outdoor

occupations that require high physical proximity to perform work tasks. In these situations, mitigation of transmission relies more heavily on the wearing of personal protective equipment and face masks. Furthermore, in indoor work settings, increasing ventilation rate and the percentage of outside air and improving air filtration have been recommended by authoritative organizations.^{20,21} These mitigation strategies would help to remove both large and small SARS-CoV-2 virus particles from indoor air.

One response to controlling the pandemic has been remote working. One study estimated that only about 37% of jobs in the U.S. can be conducted entirely at home and that these jobs are distributed unequally by industry.²² Specifically, industries with the lowest share of jobs that can be conducted at workers' homes include health care and social assistance; manufacturing; transportation and warehousing; construction; retail trade; agriculture, forestry, fishing and hunting; and accommodation and food services. Many occupations identified in our analysis that involve closer contact with others are in these industries.

As reported in a National Institute for Occupational Safety and Health blog, selected industries and occupations have been disproportionately represented among

COVID-19 cases.²³ For example, data from Washington state indicated an elevated number of cases by industry category for health care and social assistance and for agriculture, forestry, fishing, and hunting and by occupation category for healthcare practitioner and technical occupations and for healthcare support occupations.²⁴ These industry and occupational categories include some of the same occupations identified at potentially higher risk for COVID-19 on the basis of proximity and outdoor/indoor category.

Black and Hispanic workers were distributed somewhat differently in the proximity and outdoor/indoor work categories, with proportionately more Black workers in the high-proximity indoor work category and more Hispanic workers in the outdoor work categories (Table 1). In addition, results presented in Tables 2 and 3 illustrate that Black and Hispanic workers were distributed differentially in the higher-risk occupations. These differences suggest that the prevention efforts intended for workers at higher risk for exposure to SARS-CoV-2 will impact different numbers of Black and Hispanic workers depending on which occupations are targeted and the relative success of those efforts.

The Centers for Disease Control and Prevention and health departments in Utah investigated workplace COVID-19 outbreaks from March to early June 2020.²⁵ More than half of the COVID-19 cases identified in workplace outbreaks were in the 3 industry sectors of manufacturing, wholesale trade, and construction. Moreover, although Hispanic and non-White workers accounted for only 24% of workers in the 15 affected industry sectors, they accounted for 73% of the COVID-19 outbreaks. The authors noted the following about public health practice: “Mitigation strategies should be culturally and linguistically responsive to racial/ethnic minority workers disproportionately affected by COVID-19.”

Limitations

The use of the BLS OES survey data on employment has limitations because certain types of workers are not included. Employees are all part-time and full-time workers who are paid a wage or salary. The survey excludes most of the agricultural sector workers, except for logging and support activities for crop and animal production. Private households are also excluded. The survey does not cover the self-employed, owners and partners in unincorporated firms, household workers, or unpaid family workers. Military occupations are also not included. It is likely that a proportion of the workers not covered by the OES survey are in occupations over-represented by Black and Hispanic workers and in the higher-risk categories of proximity and outdoor/indoor work.

Because the data used in this study were collected before the COVID-19 pandemic, the results describe the distribution of workers in the proximity and outdoor/indoor work categories before the pandemic changed working situations, such as working from home. The designation of levels of risk for proximity and outdoor/indoor work categories also does not take into account mitigation measures such as social distancing and wearing of personal protective equipment or masks. The authors did not use all questions from O*NET that may be pertinent to risk for exposure to SARS-CoV-2. In addition, the authors did not have data to consider other possible risk factors (e.g., paid sick leave and the density of living arrangements) that could influence the risk for exposure.

CONCLUSIONS

A high proportion of U.S. workers may be at higher risk for exposure to COVID-19 because their occupations involve either high proximity to others indoors and outdoors (25.2%, 36.5 million workers) or medium-proximity indoors (48%, 69.6 million workers). There is a differential distribution of proximity and outdoor/indoor work by occupation, and in some occupations, Black and Hispanic workers are over-represented. The results from this descriptive study may help to inform interventions in workplaces to mitigate exposure risk to SARS-CoV-2. The implementation of COVID-19 preventive measures in work settings should be based on occupational risk factors, including proximity to others and outdoor/indoor work settings. Adherence to guidance for the protection of essential workers and those workers who return to work as restrictions ease across the U.S. must be emphasized.^{13,26} Prevention strategies should consider worksite conditions, and communication messages should be tailored to the languages and preferred media of the workforce.

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JMCG and PKH conceptualized and designed the study. JMCG carried out data analysis. JMCG and PKH interpreted the results, drafted the initial manuscript, and revised the manuscript.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <https://doi.org/10.1016/j.amepre.2020.12.016>.

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