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Estimated N95 Respirator Needs for Nonhealthcare Essential Workers in the United States During Communicable Respiratory Infectious Disease Pandemics

Ethan D. Fechter-Leggett [Lead Research Epidemiologist],
Respiratory Health Division, National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC), Morgantown, WV.

Kathleen B. Fedan [Statistician],
Respiratory Health Division, National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC), Morgantown, WV.

Jean M. Cox-Ganser [Associate Director for Science],
Respiratory Health Division, National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC), Morgantown, WV.

Martin I. Meltzer [Senior Health Economist],
Division of Preparedness and Emerging Infections, National Center for Emerging and Zoonotic Infectious Diseases, CDC, Atlanta, GA.

Bishwa B. Adhikari [Senior Economist],
Division of Preparedness and Emerging Infections, National Center for Emerging and Zoonotic Infectious Diseases, CDC, Atlanta, GA.

Chad H. Dowell [Deputy Associate Director]
Emergency Preparedness and Response, NIOSH, CDC, Atlanta, GA.

Abstract

Early in the COVID-19 pandemic, demand for N95 respirators far exceeded the supply, leading to widespread shortages. Initially, the US Centers for Disease Control and Prevention did not recommend N95 respirators in nonhealthcare settings, in order to reserve them for healthcare workers. As N95s became more available, the recommendations were updated in May 2021 to include N95 respirators for nonhealthcare settings. In this study, we estimated the numbers of N95s needed for nonhealthcare essential workers in the United States. This information is valuable for crisis preparedness and planning for future large-scale communicable respiratory infectious disease epidemics or pandemics. We adapted a spreadsheet-based tool originally built to estimate the potential demand for N95 respirators during an influenza pandemic. We defined nonhealthcare essential occupations according to the 2020 US Department of Homeland Security guidance and used US Bureau of Labor Statistics employment numbers and Occupational Information

Address correspondence to: Ethan D. Fechter-Leggett, DVM, MPVM, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 1000 Frederick Lane, Morgantown, WV 26508, iun8@cdc.gov.

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Network data as model parameters. We modeled minimum, intermediate, and maximum N95 provision scenarios (as 1, 2, and 5 N95 respirators, respectively) per week per worker, for pandemic durations of 15 and 40 weeks. For 85.15 million nonhealthcare essential workers during a 15-week pandemic, an estimated 1.3 billion N95 respirators would be needed under minimum provision scenarios, 2.6 billion for intermediate provision, and 6.4 billion for maximum provision. During a 40-week pandemic, these estimates increased to 3.4 billion, 6.8 billion, and 17 billion. Public health authorities and policymakers can use these estimates when considering workplace respirator-wearing practices, including prioritization of allocation, for nonhealthcare essential workers. Our novel spreadsheet-based tool can also be used to quickly generate estimates of other preparedness and response equipment.

Keywords

COVID-19; Occupational groups; Respiratory protective devices; Communicable diseases; Respiratory tract diseases; Essential workers

Introduction

The COVID-19 pandemic has highlighted the critical role of workers in society and the importance of a multilayered approach to occupational safety and health in response to respiratory infectious disease pandemics.[1] During the pandemic, the US Centers for Disease Control and Prevention (CDC) and the Occupational Safety and Health Administration have recommended the use of masks by workers to help prevent the spread of COVID-19.[2,3] Many types of masks (eg, cloth, medical procedure, surgical) and respirators are available in the United States, including filtering facepiece N95 respirators (also referred to as N95s and surgical N95s), which are approved by the US National Institute for Occupational Safety and Health (NIOSH).[4,5] N95 respirators are tight-fitting respirators designed to filter at least 95% of airborne particles, including infectious bacteria and viruses. The CDC has recommended that healthcare personnel wear N95s and other personal protective equipment (PPE) when interacting with patients with confirmed or suspected COVID-19.[6] N95s are also routinely worn by some workers for respiratory protection from workplace dusts, fumes, or particles.[7]

In December 2020, the US Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) published guidance (version 4.0) that "identifies workers who conduct a range of operations and services that are typically essential to continued critical infrastructure viability" across 18 large industry sectors.[8] CISA version 4.1, which was released in August 2021 and is largely unchanged from CISA version 4.0, can serve as the basis for defining essential critical infrastructure workers for public health surveillance, research, and interventions such as vaccine allocation.[9] The NIOSH essential worker industry and occupation code set maps workplace industry codes to CISA version 4.0 for use by public health practitioners and researchers to identify and study specific populations of essential critical infrastructure industries as defined by CISA.[10] A March 2021 publication on healthcare access among essential critical infrastructure workers mapped occupation codes to CISA guidance[11] that also enables researchers to

investigate occupation-specific risks and needs among subgroups of the essential workforce. Previous work has used standardized codes to describe differential risk of COVID-19 among certain healthcare and nonhealthcare occupations[12]; the unequal distribution of proximity to others, outdoor/indoor work, and exposure to disease or infection by occupation[13,14]; and occupational segregation of people of color into essential industries and occupations at high risk for COVID-19.[15]

The demand for respirators exceeded supplies during the COVID-19 pandemic, leading to widespread shortages and driving temporary federal authorization of the use of respiratory protective devices that, although not approved by NIOSH, conformed to select international standards.[16,17] Initially, CDC did not recommend the use of N95 respirators for protection against COVID-19 in nonhealthcare settings, in order to reserve N95 respirators for healthcare workers.[18] CDC updated the recommendations in May 2021 to state that respirators labeled as "surgical" N95s should still be prioritized for protection against COVID-19 in healthcare settings and that healthcare facilities should shift from crisis capacity strategies for optimizing N95 supplies to conventional practices. In addition, the recommendations advised that basic disposable N95s could be worn in nonhealthcare settings as N95 respirator supplies became available.[5,19] To aid public health planning for future communicable respiratory infectious disease epidemics, we sought to develop a flexible tool that could be used to estimate the numbers of PPE, supplies, or materials needed for preparedness and response among subgroups of interest. The tool can be applied to estimate the number of N95 respirators that would be needed by nonhealthcare essential workers overall, and by 2 subgroups of workers: those who work in close physical proximity to other people and those who work mostly indoors. The N95 estimates can help inform future allocation of available respiratory protective supplies based on risk of exposure.

Materials and Methods

Data Sources

We assembled a list of nonhealthcare essential occupational groups based on US Census occupation codes, as described previously,[11,20] with minor modifications to account for changes between CISA versions. The NIOSH essential worker industry and occupation code set contains an indicator that denotes changes to the essential industry designation from version 3.0 of the CISA advisory list to version 4.0. Two team members independently assessed the occupations within each industry newly designated as essential in CISA version 4.0 to identify occupations not included as essential occupations in previous CISA versions. The following occupations were newly included as essential occupations: religious workers (clergy [2040]; directors, religious activities and education [2050]; religious workers, all other [2060]), education administrators (0230), and first-line supervisors of construction trades and extraction workers (6200). To populate the occupational groups, we used national employment estimates produced from a representative sample of US households covering the civilian noninstitutional population aged 16 years and over; multiple jobholders were counted once.[20–22]

To calculate the number of N95s needed for nonhealthcare essential workers who work in close physical proximity to others or work mostly indoors, we used data from the

Occupational Information Network (O*NET). O*NET provides data on job characteristics obtained by surveying job incumbents using standardized questionnaires and input from occupational analysts and experts. We used O*NET version 24.3 (May 2020), which contains data collected from March 2002 through August 2019.[23] Data on physical proximity came from the Work Context module question on physical proximity: "How physically close to other people are you when you perform your current job?" The response options were: (1) "I don't work near other people (beyond 100 feet)," (2) "I work with others but not closely (eg, private office)," (3) "slightly close (eg, shared office)," (4) "moderately close (at arm's length)," and (5) "very close (near touching)." Data used to inform estimates of those working mostly indoors came from the following 2 questions on outdoor work: "How often does your current job require you to work outdoors, exposed to all weather conditions?" and "How often does your current job require you to work outdoors, under cover (like in an open shed)?" The response options for each of these outdoor work questions were: (1) "never," (2) "once a year or more but not every month," (3) "once a month or more but not every week," (4) "once a week or more but not every day," and (4) "every day."

Model Parameters

We adapted a spreadsheet-based tool in Microsoft Excel previously built to estimate potential demand for N95 respirators and surgical masks during an influenza pandemic and applied parameters applicable to N95s and COVID-19. N95 respirator needs were modeled for 15 broad and 22 detailed occupational groups. For each occupational group, N95 needs were modeled for the entire group of workers and 2 subgroups of workers: those who work in close physical proximity to other people and those who work mostly indoors. For close physical proximity to other people, the number of workers in each O*NET occupation who answered "moderately close (at arm's length)" or "very close (near touching)" to the O*NET physical proximity question was calculated. For those who work mostly indoors, the number of workers in each O*NET occupation who answered "once a month or more but not every week" or less frequently were calculated for each of the 2 O*NET outdoor questions; minimum and maximum percentages of each census occupation code that work mostly indoors were then algebraically calculated. The tool and detailed methods describing the calculation of these percentages for each occupational group are provided in Supplemental Material at www.liebertpub.com/doi/suppl/10.1089/hs.2021.0166)

We modeled 2 pandemic durations (15 weeks and 40 weeks) and 3 N95 usage scenarios (minimum, intermediate, and maximum provision). For the minimum provision model, we assumed 1 N95 would be provided per week per worker. For the intermediate provision model, we assumed 2 N95s would be provided per week per worker; this case assumed that if a worker donned (put on) the N95 twice per day (once at the start of the work shift and once after a meal break), each N95 could be used for 2.5 days (5 uses) to ensure adequate respirator performance.[24] For the maximum provision model, we assumed 5 N95s would be provided per week per worker; this case assumed 1 N95 per workday during a 5-day workweek to enable daily, extended use.[25]

Human Participant Protection

Institutional review board approval was not required because we used only publicly available, nonidentifiable secondary data to conduct this study. It was determined by the NIOSH Human Research Protection Program to be research not involving human subjects under 45 CFR 46.102(e).

Data Sharing

All data used in this study were publicly available from CISA,[8] NIOSH,[10] the US Census Bureau,[20] the US Bureau of Labor Statistics,[21] and the O*NET Resource Center.[23] The spreadsheet-based tool used to generate N95 estimates is available in the Supplemental Material.

Results

We estimated a total of 85.2 million nonhealthcare essential workers in the United States. The number of workers in each occupational group ranged from 9,000 (subway, streetcar, and other rail transportation workers) to 15.6 million (sales and related workers) (Table 1). Among the 15 broad occupational groups, the following 3 groups included over 10 million workers each: sales and related (15.6 million); education, training, and library (10.4 million); and transportation and material moving (10.1 million). In 2 of the broad occupational groups, over 80% of workers worked in close physical proximity (postal service clerks, 92.9%; personal care and service, 82.9%). In 4 broad occupational groups, more than 80% of workers might work mostly indoors (food preparation and serving related, 87.2%; community and social services, 85.2%; postal service clerks, 80.5%; education, training, and library, 80.2%). Among the 22 detailed occupational groups, 2 groups with the highest percentages of workers who work in close physical proximity to others also had over 85% of workers who might work mostly indoors: flight attendants (100% in close physical proximity, up to 99.6% mostly indoors) and supervisors, food preparation and serving related (93.2% in close physical proximity, up to 88.0% mostly indoors).

For all nonhealthcare essential workers during a 15-week pandemic, an estimated 1.3 billion N95 respirators would be needed under minimum provision, 2.6 billion under intermediate provision, and 6.4 billion under maximum provision scenarios. During a 40-week pandemic, these estimates increase to 3.4 billion (minimum), 6.8 billion (intermediate), and 17.0 billion (maximum) (Table 2).

Among the broad occupational groups, the sales and related occupational group had the largest estimated N95 needs (Figure 1). Estimated N95 needs during a 40-week pandemic and maximum provision scenario were greater than 1 billion for 8 broad occupational groups: (1) sales and related; (2) education, training, and library; (3) transportation and material moving; (4) production; (5) food preparation and serving related; (6) construction trades workers; (7) personal care and service; and (8) building and grounds cleaning and maintenance.

Among the detailed occupational groups, retail sales workers and cashiers had the largest estimated N95 needs. In addition, 2 food-related occupational groups, both under the broad

occupational group of food preparation and serving related, were represented among the detailed occupational groups with the largest estimated N95 needs under the 3 provision scenarios (Table 2). Food and beverage serving workers would need 49 million (minimum), 98 million (intermediate), and 244.9 million (maximum) N95s for a 15-week pandemic; and 130.6 million (minimum), 261.2 million (intermediate), and 653 million (maximum) for a 40-week pandemic. Cooks and food preparation workers would need 46.7 million (minimum), 93.3 million (intermediate), and 233.3 million (maximum) N95s for a 15-week pandemic; and 124.4 million (minimum), 248.8 million (intermediate), and 622 million (maximum) for a 40-week pandemic. Food processing workers, under the broad occupational group of production, would need 11.6 million (minimum), 23.2 million (intermediate), and 58.1 million (maximum) for a 15-week pandemic; and 31 million (minimum), 61.9 million (intermediate), and 154.8 million (maximum) for a 40-week pandemic. Estimated N95 needs under the maximum provision scenario were over 100 million for 8 of the 22 (36%) detailed occupational groups for a 15-week pandemic and 17 (77%) for a 40-week pandemic.

For some occupational groups, the difference between the estimated N95 needs for the entire group and the needs of the 2 subgroups—those who work in close physical proximity to others and those who work mostly indoors— varied less than other occupational groups (Figure 2). The estimated N95 needs for the entire group and the 2 subgroups were more similar for the broad occupational groups of food preparation and serving related; personal care and service; protective service; community and social services; and farming, fishing, and forestry than other occupational groups. The N95 needs were similar because of the relatively larger percentages working in close physical proximity to others or mostly indoors or overall smaller estimated number of workers. These results are in contrast to other occupational groups (eg, sales and related; education, training, and library; transportation and material moving; construction trades workers; and building and grounds cleaning and maintenance) where estimated N95 needs for the 2 subgroups were substantially smaller than estimates for the entire group of workers. The subgroup N95 estimates were at least 500 million fewer than the entire group because of the relatively smaller percentages of workers who work in close physical proximity to others or work mostly indoors or the overall larger estimated number of workers. For the broad occupational group that had the largest number of workers, sales and related, 62.7% of workers reported working in close physical proximity to others, which translated to 2 billion N95s needed, compared with 3.1 billion N95s for the entire group, for a 40-week pandemic under maximum provision; similarly, 66.8% to 75.2% workers might work mostly indoors, which translated to a smaller decrease in needed N95s at 2.1 to 2.3 billion compared with 3.1 billion for the entire group.

Discussion

Using this framework for estimating N95 needs among essential occupational groups, we calculated up to 17 billion N95 respirators would be needed to provide all nonhealthcare essential workers with 5 N95s per week during a 40-week pandemic. Lower estimates were achieved by assuming a shorter pandemic duration of 15 weeks (6.4 billion N95s) and 1 N95 per week during a 40-week pandemic (3.4 billion N95s). The lowest estimate of 1.3 billion N95s was attained by assuming the shorter pandemic duration of 15 weeks and 1

N95 per week for all nonhealthcare essential workers. In contrast, up to 3.6 billion N95s have been estimated for healthcare workers alone over the course of the pandemic, and the US Strategic National Stockpile contained 24 million N95s in January 2020.[26,27] In an experimental study of healthcare workers, reuse of contaminated respirators resulted in contamination of the surrounding environments and personnel.[28] Because nonhealthcare workers might not have backgrounds in infection prevention and control or access to decontamination procedures and equipment, providing 5 N95s per week may be preferable, meaning the larger N95 estimates presented here could better approximate the potential needs of these nonhealthcare essential workers.

Consistency of N95 products and their availability over time would also need to be addressed. In the United States, when employees are required to wear an N95 in the workplace, the Occupational Safety and Health Administration requires employers to implement a written respiratory protection program, including required annual fit testing for proper respirator size that confirms a proper seal.[29] Implementing such programs for employees in occupations that do not typically involve respirator fit testing could be a substantial undertaking, especially in the midst of a communicable respiratory infectious disease epidemic or pandemic. During the COVID-19 pandemic, the Occupational Safety and Health Administration temporarily exercised enforcement discretion regarding annual fit testing requirements; however, initial fit tests were still required. “Just-in-time” fit testing methods have also been developed for use during public health emergencies that enable fit testing large numbers of workers in a short period of time.[30]

The results presented in this article are specific to N95s, although the need for N95s could be reduced through the use of other types of respiratory protection that are reusable, such as elastomeric half-face respirators or powered air-purifying respirators. However, these other types of respiratory protection might not be appropriate for all occupations.[31] The estimated N95 needs for many groups remained in the hundreds of millions even under the shorter pandemic duration of 15 weeks, N95 reuse scenarios, or provision of N95s only to subgroups who work in close physical proximity to others or mostly indoors. These results highlight the importance of using a layered strategy to reduce workplace exposure to novel communicable respiratory infectious pathogens such as SARS-CoV-2. Preferred methods to reduce workplace hazards should follow the hierarchy of controls, a framework that ranks controls in order of their potential effectiveness and ability to protect workers from hazards; elimination of a hazard is potentially the most effective control while PPE, such as respiratory protection, requires substantial efforts by both workers and employers for effectiveness.[32] While correct use of N95s can help prevent hazardous exposures, PPE such as N95s is considered the last method of defense among the components of workplace hazard mitigation strategies. Control strategies for future communicable respiratory infectious disease epidemics or pandemics could benefit from the multilayered approach to COVID-19 mitigation that includes (1) community and workplace vaccination programs, (2) engineering controls such as modifying the physical environment to accommodate physical distancing and ventilation modifications that may reduce exposures to the infectious pathogen, (3) administrative controls such as telework options that minimize contact among employees, and (4) routine cleaning and disinfection.[2,3,33]

Prioritizing employees who work in close physical proximity to others or mostly indoors could also reduce N95 needs, although our results indicate the potential reduction in number of N95s needed varies widely by occupational group, and other strategies could be used to help meet demands for respiratory protection. In February 2021, ASTM International published "ASTM F3502–21: Standard Specification for Barrier Face Coverings"[34] to provide guidance on design, source control performance, comfort, and reuse of barrier face coverings. The ASTM guidance uses the term "barrier face coverings" to distinguish them from other types of masks. This standard specifies performance criteria as a combination of filtration efficiency (ie, effectiveness of capturing small particles, applicable to both source control and protection) and airflow resistance (ie, breathability). Filtration performance is classified into 2 levels: greater than or equal to 20% and greater than or equal to 50%. Masks meeting ASTM F3502–21 standard are not medical masks or respirators, but the standard could help all workers identify products that provide a certain level of source control and protective capability when used properly. While the ASTM criteria addresses filtration and breathability, NIOSH has recommended additional workplace mask criteria that builds upon the ASTM standard by requiring leakage ratios of greater than or equal to 5 for Workplace Performance masks and greater than or equal to 10 for Workplace Performance Plus masks.[35,36] Leakage was defined as the "ratio of the particle concentration outside the face covering over particle concentration inside the face covering,"[36] with higher leakage ratios indicating better source control.[35,36] NIOSH has published a list of barrier face coverings and Workplace Performance/Performance Plus masks that conform to these requirements[36]; use of these barrier face coverings could help protect workers and those around them when used alongside other public health measures to reduce infection transmission, including getting vaccinated and boosted, physical distancing, washing hands, and staying home when sick or after being exposed to someone who is sick.

Our findings are subject to limitations. Percentages of occupational groups that work in close physical proximity to others or work mostly indoors might not reflect changes in work practices in response to the COVID-19 pandemic, such as teleworking. However, we used the most recent O*NET data collected before the COVID-19 pandemic to demonstrate N95 needs during typical work practices that many businesses could strive to achieve. The 2 O*NET questions on outdoor work do not specifically ask about indoor work; therefore, we used both outdoor questions and algebraic calculations to generate a percentage range for mostly indoor work by occupational group. For some occupational groups, the mostly indoor work measure used here might not indicate work inside a physical building, but rather an enclosed area such as a bus, taxi, or airplane. Furthermore, this measure is not necessarily synonymous with poorly ventilated areas that lack recommended ventilation strategies that can reduce viral particle concentrations. For COVID-19 specifically, ventilation recommendations have been published for general buildings and specific industries as part of a multilayered approach to reduce exposures to SARS-CoV-2.[37–40] There might also be other O*NET measures relevant to potential respiratory infectious pathogen exposure that we did not consider. Additionally, for some infectious diseases, such as COVID-19, risk for all workers is not independent of community-level transmission, and our study does not include a community-based measure of transmission that could be used to adjust local N95 demands. The results presented in this article are specific to the described N95 provision and

pandemic duration assumptions, and the spreadsheet-based tool we used could be used for other worker groups, N95 provision levels, and pandemic durations.

Conclusion

We developed and applied a flexible tool for estimating N95 needs among occupational groups. Public health authorities and policymakers can use our findings and the spreadsheet-based tool when considering workplace respirator recommendations for nonhealthcare settings, including who should wear respirators and when, among workers who are considered essential[8] and when examining stockpile inventories and practices for future communicable respiratory infectious disease epidemics or pandemics. This framework for estimating N95 needs by occupational group could also be used to generate estimates for other industries or occupations under different timelines, respirator types, or respirator usage scenarios at national, state, or local levels for any situation involving the use of N95 respirators. The ability to rapidly generate such estimates could be imminently useful given the emergence and evolution of SARS-CoV-2 variants, incompletely understood longevity of infection-induced and vaccine-induced COVID-19 immunity, and potential for future noncoronavirus epidemics or pandemics. While we have used N95 respirators in response to the COVID-19 pandemic and produced estimates by 2 subgroups of workers, based on physical proximity and indoor/outdoor work, more broadly our novel spreadsheet-based tool could be applied to estimate other types of preparedness and response PPE, supplies, or materials and for other subgroups of interest. Finally, in addition to proper use of respiratory protection when indicated, hazard controls should be implemented in all workplaces as part of a comprehensive respiratory infectious disease mitigation strategy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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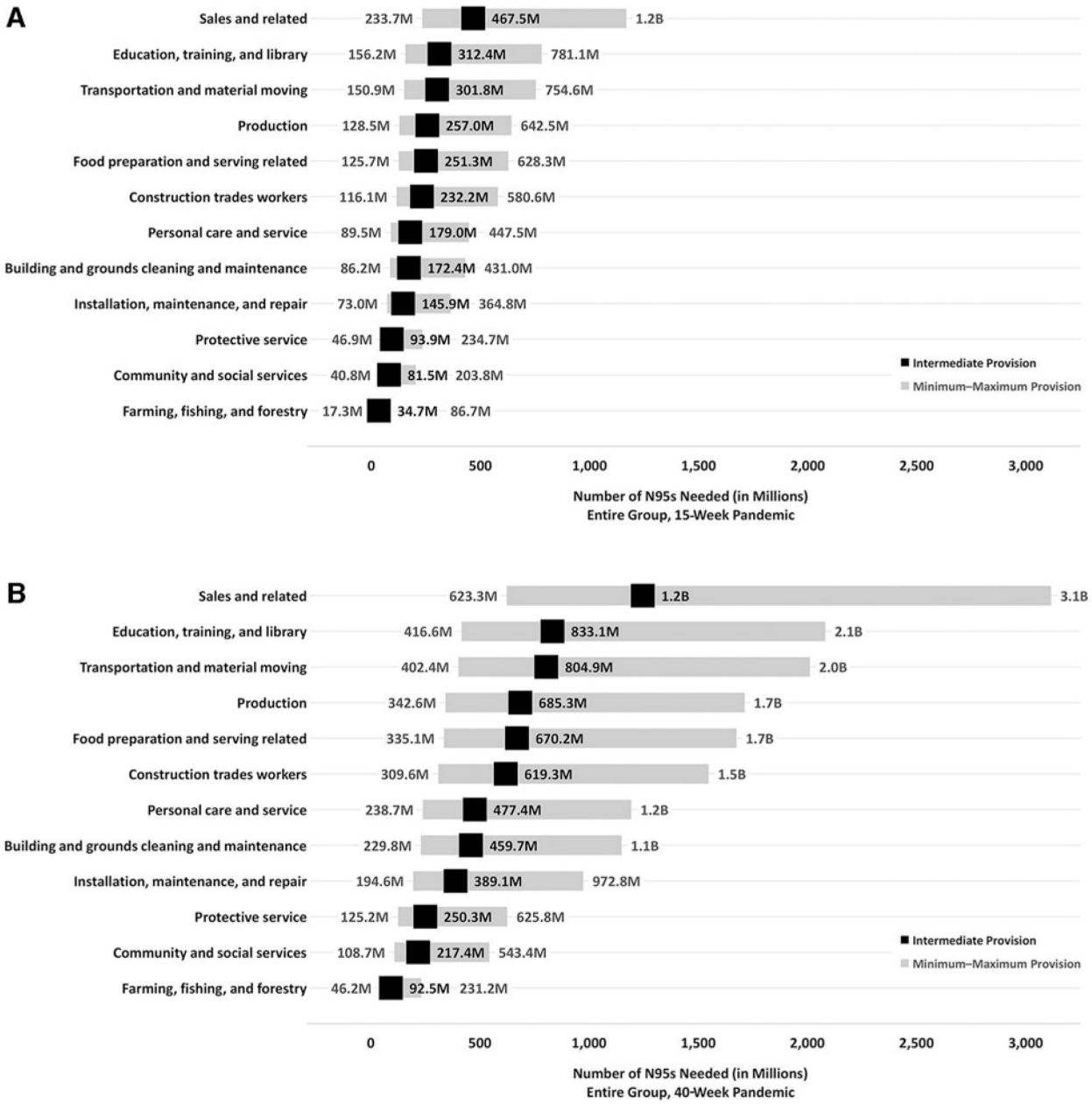

Figure 1.

Comparison of the estimated number, in millions (M) or billions (B), of N95 respirators needed for all workers in selected nonhealthcare essential occupational groups between (A) 15-week and (B) 40-week duration pandemics.

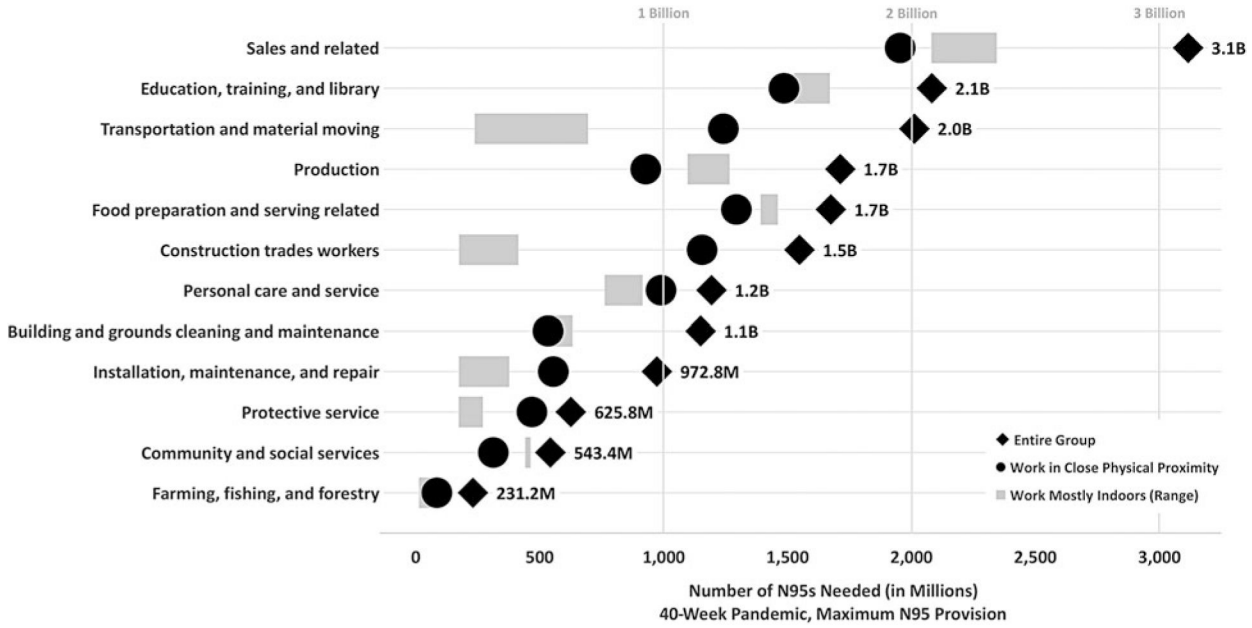

Figure 2.

Estimated number, in millions (M) or billions (B), of N95 respirators needed for (1) all workers (entire group), (2) those who work in close physical proximity, and (3) those who work mostly indoors in selected nonhealthcare essential occupational groups. These estimates are for a 40-week duration pandemic, assuming maximum provision of 20 N95s for each worker per month. Detailed methods describing calculation of percentages for each occupational group that works in close physical proximity and mostly indoors are provided in the Supplemental Material (www.liebertpub.com/doi/suppl/10.1089/hs.2021.0166).

Table 1.

Nonhealthcare Essential Workers Aged 16 Years and Over, Overall and by Broad and Detailed Occupational Groups

Occupational Group	2010 Census Occupation Code[a]	Number of Workers[b]	% Working in Close Proximity to Other People[c]	% Working Mostly Indoors[d]	
				Min.	Max.
All nonhealthcare essential occupations	—	85,150,000	65.0	50.6	62.2
Broad and detailed essential occupations					
Community and social services	2000–2060	2,717,000	57.6	81.3	85.2
Religious workers	2040–2060	554,000	50.8	98.7	98.7
Education, training, and library	0230, 2200–2550	10,414,000	71.3	73.3	80.2
Protective service	3700–3955	3,129,000	75.0	27.7	43.3
Firstline supervisors/managers, protective service workers	3700–3730	247,000	75.1	9.6	21.0
Firefighting and prevention workers	3740–3750	339,000	88.1	0.0	11.9
Law enforcement workers	3800–3860	1,265,000	76.8	17.5	36.2
Other protective service workers	3900–3955	1,278,000	69.6	47.6	61.5
Food preparation and serving related	4000–4160	8,377,000	77.2	83.1	87.2
Supervisors, food preparation and serving-related workers	4000–4010	1,071,000	93.2	86.1	88.0
Cooks and food preparation workers	4020–4030	3,110,000	65.3	86.8	89.4
Food and beverage serving workers	4040–4120	3,265,000	83.3	84.3	87.5
Other food and preparation and serving-related workers	4130–4160	931,000	77.3	62.7	77.5
Building and grounds cleaning and maintenance	4200–4250	5,746,000	46.4	45.5	55.0
Janitors and building cleaners	4220	2,265,000	40.6	47.2	67.2
Maids and housekeeping cleaners	4230	1,475,000	44.1	90.3	92.9
Personal care and service	4300–4650	5,967,000	82.9	63.9	76.6
Funeral service workers	4460–4465	41,000	72.7	6.9	34.7
Childcare workers	4600	1,193,000	77.1	14.3	53.6
Personal care aides	4610	1,458,000	88.4	82.1	82.1
Sales and related	4700–4965	15,583,000	62.7	66.8	75.2
Retail sales workers and cashiers	4720–4760	6,508,000	76.6	68.7	78.8
Couriers and messengers	5510	402,000	30.8	32.9	48.7
Postal service clerks	5540	96,000	92.9	61.1	80.5
Postal service mail carriers	5550	331,000	34.9	0.0	0.0

Occupational Group	2010 Census Occupation Code[a]	Number of Workers[b]	% Working in Close Proximity to Other People[c]	% Working Mostly Indoors[d]	
				Min.	Max.
Farming, fishing, and forestry	6005–6130	1,156,000	37.0	5.7	25.2
Construction trades workers	6200–6540	7,741,000	74.6	11.3	26.7
Construction laborers	6260	2,051,000	67.2	0.0	11.1
Installation, maintenance, and repair	7000–7630	4,864,000	57.1	17.9	38.8
Production	7700–8965	8,566,000	54.1	64.0	73.9
Food processing workers	7800–7855	774,000	67.8	84.9	88.3
Transportation and material moving	9000–9750	10,061,000	61.7	11.8	34.5
Flight attendants	9050	110,000	100.0	99.6	99.6
Bus drivers	9120	546,000	86.4	18.9	42.9
Driver/sales workers and truck drivers	9130	3,608,000	55.8	0.0	14.3
Taxi drivers and chauffeurs	9140	790,000	88.9	0.0	25.0
Subway, streetcar, and other rail transportation workers	9260	9,000	63.7	0.0	26.5

[a] 2010 version of the US Census Bureau occupation numeric codes.[20]

[b] Employed persons, US Bureau of Labor Statistics Current Population Survey, 2019 Annual Averages Household Data.[21]

[c] Defined as "'Moderately close (at arm's length)" or "Very close (near touching)" response on the O*NET physical proximity question "How physically close to other people are you when you perform your current job?"[23]

[d] Defined as "Once a month or more but not every week" or less frequently response on the O*NET outdoor work questions "How often does your current job require you to work outdoors, exposed to all weather conditions?" and "How often does your current job require you to work outdoors, under cover (like in an open shed)?"[23] Minimum and maximum values calculated using algebraic calculations described in Supplemental Material (www.liebertpub.com/doi/suppl/10.1089/hs.2021.0166).

Table 2.

Estimated Number of N95 Respirators (In Millions) Needed for All Nonhealthcare Essential Workers by Occupational Group

	15-Week Pandemic			40-Week Pandemic		
Occupational Group	**Minimum Provision**	**Intermediate Provision**	**Maximum Provision**	**Minimum Provision**	**Intermediate Provision**	**Maximum Provision**
All nonhealthcare essential occupations	1,277.250	2,554.500	6,386.250	3,406.000	6,812.000	17,030.000
Broad and detailed essential occupations						
Community and social services	40.755	81.510	203.775	108.680	217.360	543.400
Religious workers	8.310	16.620	41.550	22.160	44.320	110.800
Education, training, and library	156.210	312.420	781.050	416.560	833.120	2,082.800
Protective service	46.935	93.870	234.675	125.160	250.320	625.800
Firstline supervisors/managers, protective service workers	3.705	7.410	18.525	9.880	19.760	49.400
Firefighting and prevention workers	5.085	10.170	25.425	13.560	27.120	67.800
Law enforcement workers	18.975	37.950	94.875	50.600	101.200	253.000
Other protective service workers	19.170	38.340	95.850	51.120	102.240	255.600
Food preparation and serving related	125.655	251.310	628.275	335.080	670.160	1,675.400
Supervisors, food preparation and serving-related workers	16.065	32.130	80.325	42.840	85.680	214.200
Cooks and food preparation workers	46.650	93.300	233.250	124.400	248.800	622.000
Food and beverage serving workers	48.975	97.950	244.875	130.600	261.200	653.000
Other food preparation and serving-related workers	13.965	27.930	69.825	37.240	74.480	186.200
Building and grounds cleaning and maintenance	86.190	172.380	430.950	229.840	459.680	1,149.200
Janitors and building cleaners	33.975	67.950	169.875	90.600	181.200	453.000
Maids and housekeeping cleaners	22.125	44.250	110.625	59.000	118.000	295.000
Personal care and service	89.505	179.010	447.525	238.680	477.360	1,193.400
Funeral service workers	0.615	1.230	3.075	1.640	3.280	8.200
Childcare workers	17.895	35.790	89.475	47.720	95.440	238.600
Personal care aides	21.870	43.740	109.350	58.320	116.640	291.600
Sales and related	233.745	467.490	1,168.725	623.320	1,246.640	3,116.600
Retail sales workers and cashiers	97.620	195.240	488.100	260.320	520.640	1,301.600
Couriers and messengers	6.030	12.060	30.150	16.080	32.160	80.400

Occupational Group	15-Week Pandemic			40-Week Pandemic		
	Minimum Provision	Intermediate Provision	Maximum Provision	Minimum Provision	Intermediate Provision	Maximum Provision
Postal service clerks	1.440	2.880	7.200	3.840	7.680	19.200
Postal service mail carriers	4.965	9.930	24.825	13.240	26.480	66.200
Farming, fishing, and forestry	17.340	34.680	86.700	46.240	92.480	231.200
Construction trades workers	116.115	232.230	580.575	309.640	619.280	1,548.200
Construction laborers	30.765	61.530	153.825	82.040	164.080	410.200
Installation, maintenance, and repair	72.960	145.920	364.800	194.560	389.120	972.800
Production	128.490	256.980	642.450	342.640	685.280	1,713.200
Food processing workers	11.610	23.220	58.050	30.960	61.920	154.800
Transportation and material moving	150.915	301.830	754.575	402.440	804.880	2,012.200
Flight attendants	1.650	3.300	8.250	4.400	8.800	22.000
Bus drivers	8.190	16.380	40.950	21.840	43.680	109.200
Driver/sales workers and truck drivers	54.120	108.240	270.600	144.320	288.640	721.600
Taxi drivers and chauffeurs	11.850	23.700	59.250	31.600	63.200	158.000
Subway, streetcar, and other rail transportation workers	0.135	0.270	0.675	0.360	0.720	1.800