

1 Characterizing occupations that cannot work from home: a means to identify susceptible worker  
2 groups during the COVID-19 pandemic

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8

## 9 Abstract

### 10 Introduction

11 As the COVID-19 pandemic spreads globally, public health guidance is advising all workers to  
12 work from home. However, not all workers are employed in occupations which can be done  
13 from home. These workers are at an increased risk for exposure to SARS-CoV-2 due to  
14 increased interaction with the public and other workers, and also potentially at an increased risk  
15 for job displacement as more extreme public health measures (such as closing of retail  
16 operations or enforcing shelter in place) occur.

### 17 Methods

18 To characterize the occupations least likely to be able to work from home, national employment  
19 and wage data maintained by the United States Bureau of Labor Statistics (BLS) was merged  
20 with measures from the BLS O\*NET survey data, which ranks occupations by a variety of  
21 physical, ergonomic, psychosocial, and structural exposures. Noting that the work that could  
22 most easily be done at home would be work done on a computer that does not rely on  
23 interaction with the public, O\*NET measures quantifying the importance of computer use at  
24 work, and the importance of working with or performing for the public at work were utilized.

### 25 Results

26 From this analysis, 19.5% (28.2 M) of the United States workforce covered by O\*NET are  
27 employed in occupations where working from home would be difficult, due to minimal use of  
28 computer at work, and a high level of interaction with the public. These workers tend to be in  
29 service occupations, including retail and food service, protective service occupations, and  
30 transportation occupations such as bus drivers. About 25% (35.6 M) of the United States

31 workforce covered by O\*NET are employed in occupations where working from home could  
32 likely be more easily accommodated, as these workers do much of their work on computers and  
33 interaction with the public is not important. These workers tend to be in technology, computer,  
34 management, administrative, financial, engineering, and some science occupations, which  
35 typically have higher pay than occupations which cannot be done at home.

## 36 **Conclusions**

37 The workers in occupations that have minimal computer use, and high interaction with the public  
38 are least likely to be able to work from home during a public health emergency. These workers  
39 could also be at an increased risk for job displacement if public-facing establishments close or  
40 alter their business model in the face of increased public health restrictions. Occupations where  
41 working from home is not possible tend to have lower annual median incomes than occupations  
42 where working from home is possible, increasing the vulnerability of these workers.  
43 Characterizing which occupational groups are least likely to be able to work from home can  
44 inform public health risk management and prioritize occupational sectors where additional  
45 workplace protections are necessary.

46

## 47 **Introduction**

48 Initial public health guidance for workers during the 2019-2020 COVID-19 pandemic was  
49 focused on ensuring workers stay home when sick, minimize non-essential travel, and practice  
50 good hygiene in order to slow the transmission of disease between workers and community  
51 members (1). As the number of cases continued to grow, and community transmission was  
52 apparent, subsequent guidance focused on encouraging all workers to work from home, with  
53 many workplaces adopting a work from home requirement (2,3). In many parts of the country,  
54 schools were closed or moved fully online (4,5), retail establishments closed or severely  
55 reduced hours (6,7), and bar and restaurants either closed or moved to a model of takeout and  
56 delivery only (8,9). This public health guidance, while necessary for halting the spread of a  
57 global pandemic such as COVID-19, can have drastic effects on workers.

58 When thinking about worker health during a pandemic crisis, exposure to disease or infection is  
59 often the first thought, particularly for front line workers such as those in healthcare sectors.

60 Previously, we calculated the burden of workers in occupations where exposure to infection or  
61 disease occurs at least weekly or monthly using United States Bureau of Labor Statistics (BLS)

62 occupational employment and O\*NET data (10). From this analysis, we found that about 18% of  
63 the workforce is exposed to disease or infection at least once a month at work, making these  
64 workers at increased susceptibility to not only contracting a disease due to work, but also  
65 transmitting a disease into the community.

66 While disease exposure is an important occupational health concern during a pandemic, job  
67 security is another important metric of worker health to consider during a pandemic. Several  
68 researchers have shown a relationship between acute and chronic job insecurity and measures  
69 of adverse physical and mental health outcomes including depression, stress, and physiologic  
70 markers such as increased blood pressure (11–14). Job displacement, or involuntary job loss  
71 stemming from a layoff, downsizing, or plant closure, also has been shown to be related to a  
72 variety of adverse mental health outcomes including depression, suicide, and stress (15–18),  
73 negative changes in diet (19,20), and physical health outcomes such as coronary heart disease  
74 and other physiologic markers of adverse health (21,22). After a job displacement event,  
75 workers may take jobs of lower quality, resulting in long-term economic and psychosocial effects  
76 for once-displaced workers (23). Additionally, with many workers in the United States receiving  
77 healthcare and other benefits from their work arrangement, a layoff or reduction in hours can  
78 affect access to healthcare or long term stability for these workers (24).

79 For many workers, being able to work productively from home is one way to continue to work  
80 through a public health emergency, such as COVID-19. Working from home allows these  
81 workers continued job security, access to healthcare and other benefits, and a full paycheck  
82 while still allowing them to practice social distancing and reduce contact with other people.  
83 However, it is known that not all workers are able to work from home due to differences in job  
84 tasks. Jobs that lend themselves to being completed at home are jobs that require limited  
85 interaction with the public, so the work can be done in relative solitary. Additionally, jobs that  
86 primarily use a computer to complete tasks may lend themselves to be done at home, given the  
87 portability of laptop computers.

88 Here, I characterize which, and how many United States workers are likely to not be able to  
89 work from home, due to high importance of interaction with the public at work, and limited  
90 importance of computer use at work. Additionally, I investigate whether median annual wages  
91 differ between occupations where work from home can occur, and occupations that cannot be  
92 done at home, therefore making workers in these jobs more susceptible to voluntary or  
93 involuntary layoff or hours reduction as child care and schooling is moved home (due to school

94 closures), retail establishments close, and public interaction decreases due to social distancing  
95 measures.

96

## 97 Methods

98 This analysis utilized measures from two existing data sources, as previously detailed in Baker  
99 et al. (10) and Doubleday et al. (25). Briefly, United States employment by occupation, and  
100 median annual wage by occupation, was downloaded from the United States Bureau of Labor  
101 Statistics (BLS) Occupational Employment Statistics database (26). These data were last  
102 updated in May 2018, and give a count of the number of United States workers employed and  
103 the national median annual wage for each 2010 Standard Occupational Classification code  
104 (2010 SOC). Guidance around SOC codes is detailed elsewhere (27) but briefly, SOC codes  
105 range from two digits (Major Group Code) to six digits (Detailed Occupation Code) and are  
106 hierarchical in nature. For this analysis, six-digit occupation codes were utilized, and then  
107 aggregated over larger occupational groupings (i.e. two-digit codes).

108 To estimate the number of workers and types of occupations that would not be able to work  
109 from home, two measures from the O\*NET database were utilized. O\*NET is a survey that asks  
110 employees and employers across nearly all SOC codes about exposures encountered at work,  
111 knowledge and skills utilized in the occupation, types of tasks performed, and workplace  
112 characteristics (28). O\*NET does not collect data from military occupations; thus, SOC codes  
113 beginning with 55 “Military Specific Occupations” are not included in O\*NET data. Similarly,  
114 employment numbers for “Military Specific Occupations” is not reported in the BLS Occupational  
115 Employment Statistics Database. All other SOC codes are included in the O\*NET database,  
116 with updates made every year to ensure the database is completely refreshed every few years  
117 (29). Over a ten-year period (2001 to 2011) over 150,000 employees from 125,000 workplaces  
118 had responded to the O\*NET questionnaire, making it a robust source of occupational  
119 information (30).

120 Two O\*NET measures were utilized in this analysis. The first characterized the importance of  
121 computer use at work via the question, “How important is working with computers to the  
122 performance of your current job?”. The second O\*NET question investigated was, “How  
123 important is performing for or working directly with the public to the performance of your current  
124 job?” For both questions, respondents could select from the following multiple choice answers:

125 Not Important, Somewhat Important, Important, Very Important, Extremely Important. Both of  
126 these measures are converted to a 0-100 score within O\*NET, representing weighted-average  
127 score for each SOC code. A score of 50 is equivalent to a respondent answering “important” for  
128 both of the questions considered in this analysis.

129 Importance scores for both O\*NET metrics were merged with the national employment data and  
130 annual median wage data. Both O\*NET measures were plotted against each other, with the  
131 resultant scatterplot divided into four quadrants. The upper left quadrant represents jobs where  
132 computer use is rated as “Important” or higher, but performing for or working directly with the  
133 public was rated as less than important; jobs that could easily be done at home. The lower right  
134 quadrant represents jobs where computer use was rated as less than “Important” but performing  
135 for or working directly with the public was rated as “Important” or higher; jobs which would not  
136 be easily to perform at home. Each SOC on the scatterplot was weighted by annual median  
137 wage, to visualize differences in income between the four quadrants.

138 To further explore relationships in these data, the distribution of median annual wages was  
139 compared between quadrants using an ANOVA.

140 All data analysis was conducted using the statistical software package R version 3.6.3.

141

## 142 Results

143 BLS reports a total of 144.7 million persons employed in the United States in May 2018; this  
144 number does not include workers in military occupations or in jobs that comprise the gig  
145 economy, such as app-based drivers. Figure 1 shows the relationship between “Importance of  
146 computer use at work” and “Importance of interaction with or performing for the public at work”  
147 for all SOC codes. Each SOC plotted here is sized in proportion to the national median annual  
148 wage reported for that occupation by BLS, with larger points denoting a higher median annual  
149 wage. Each SOC on the plot is color-coded broadly by occupational sector

150 Figure 1 is divided into four quadrants. SOCs in the upper left quadrant represent those  
151 occupations that most lend themselves to being done at home, that is, computer use is  
152 important to the work, but interaction with the public is not important. As detailed in Table 2, this  
153 quadrant represents 24.6% (35.6 M) of the workforce covered by BLS and tends to include

154 occupational sectors such as administration, finance, management, computer, technical,  
155 science, engineering, and architecture occupations.

156 The bottom right quadrant in Figure 1 represents occupations that likely cannot be done at  
157 home, due to the fact that computer work is not important, and interaction with the public is  
158 important. As detailed in Table 2, this quadrant is 19.5% of the workforce covered by BLS (28.2  
159 M workers) and consists of occupational sectors such retail, food service, beauty services (e.g.  
160 barbers, hairdressers, manicurists), protective services, and transportation operators such as  
161 bus drivers or subway operators.

162 The other two quadrants on Figure 1 represent professions where interaction with the public and  
163 computer use are important (upper right quadrant; largely including education, healthcare, and  
164 sales in addition to some administration and management jobs) and where interaction with the  
165 public and computer are both not important (lower left quadrant; largely including production,  
166 transportation, natural resources, construction, and maintenance).

167 Table 1 summarizes the distribution of median annual wages in each quadrant. A one-way  
168 ANOVA indicated that the median annual wage between these quadrants were significantly  
169 different.

170

## 171 Discussion

172 During the COVID-19 pandemic, workers across the world were instructed to work from home in  
173 order to increase social distancing and ultimately halt disease transmission. However, not all  
174 workers can effectively perform work duties from home, and this analysis estimates the number  
175 of workers that may not be able to work from home using two O\*NET metrics. Additionally, this  
176 work investigates what types of occupations are most and least likely to be able to work from  
177 home, and investigates differences in annual median wage between these groups of workers.  
178 Several other data sources quantify the number of American workers that work from home, such  
179 as data collected from the American Time Use Survey, United States Census American  
180 Community Study, or the National Compensation Survey. However, these data sources are not  
181 able to quantify how many which types of workers have work that can be done at home (e.g.  
182 during a public health emergency when workers are ordered to work from home) but rather  
183 which workers have access to a remote working benefit as part of a compensation package,  
184 whether or not a respondent took advantage of it (31), or worked from home on the day the

185 survey was administered, regardless of whether it was paid work or not (32,33). The work  
186 presented here is novel, as it uses existing data sources to attempt to quantify the number and  
187 types of workers who could do work from home if working from home was ordered in an  
188 emergency situation, regardless of whether a worker typically works from home, or are typically  
189 given permission to work from home from their workplace.

190 During a pandemic, such as COVID-19, not being able to work from home could make workers  
191 particularly susceptible for adverse occupational health outcomes. Notably, this could be  
192 exposure to disease or infection in the workplace due to increased interaction with the public or  
193 coworkers in the workplace, and commuting to and from the workplace. Also importantly, not  
194 being able to work from home could also make workers job insecure. These workers are  
195 particularly vulnerable to being laid off or facing reductions in hours as the public chooses to  
196 stay home and not interact with many public-facing occupations, or if the public-facing  
197 occupations are asked to close or restrict services (such as restaurants being restricted to only  
198 takeout or delivery) as was practice during the COVID-19 pandemic. Additionally, if schools  
199 close, as happened during the COVID-19 pandemic, workers that cannot work from home may  
200 be forced to choose between staying home with children, or going into work without adequate  
201 back-up care for their children, further contributing to a feeling of insecure employment.  
202 Understanding the unique challenges that these workers could face during a pandemic or other  
203 public health emergency can help to inform appropriate risk management and policy-based  
204 strategies for these workers, to ensure that their livelihood can continue. This could include  
205 increased access to paid sick leave, guaranteed hours even if hours are cut, access to  
206 emergency childcare services, access to unemployment that pays full wage replacement,  
207 priority hiring for other related jobs, and subsidized healthcare even if layoff occurs.

208 Additionally, this analysis showed that the distribution of median annual wages differed between  
209 those workers that would be likely to work from home, and those workers that would likely not  
210 be able to work from home, further adding to the vulnerability of these workers. It is, on average,  
211 higher paid workers who are able to work from home, thus ensuring some continuity in pay,  
212 increased ability to care for a child out of school, decreased risk of being laid off or having hours  
213 substantially cut, and decreased potential exposure to disease or infection via other workers or  
214 community members

215 Given this analysis relied on existing data sources, some limitations must be acknowledged.  
216 BLS data does not count self-employed (including gig economy workers), undocumented,  
217 contingent, and domestic workers. Many workers in these groups likely are performing work

218 tasks that cannot be done at home, and are of a lower-income. Therefore, it is likely that the  
219 number of American workers who cannot work from home is underestimated in this analysis, as  
220 it does not include the groups listed above. As for O\*NET, it is important to remember that  
221 results are aggregated on the occupation level, and therefore doesn't account for within-job  
222 variation (34). Additionally, O\*NET relies on employee and employer self-report, so is subject to  
223 inherent bias and misclassification. The O\*NET metrics used in this analysis were measures of  
224 the importance of using a computer for work and importance of interacting with the public, which  
225 differs from the frequency of using a computer or interacting with the public. Therefore, some  
226 jobs for which computer use is rated as very important, may not actually require use of a  
227 computer very frequently, and jobs where interaction with the public is important may not do it  
228 frequently. This would lead to some misclassification in the analysis for who could work from  
229 home most easily.

230 In conclusion, this work shows that a large proportion of the United States workforce are in jobs  
231 that may not be easy to do at home. These are workers primarily in food service, retail, the arts  
232 and sports, beauty services (e.g. barbers, hairdressers, manicurists), and transportation  
233 operators such as bus drivers or subway operators. These workers tend to be lower-paid than  
234 workers who can do jobs from home, further increasing their vulnerability if they lose their job,  
235 have a reduction in hours, or have to quit due to childcare responsibilities or due to illness. It is  
236 important that these workers be the focus of public health and policy interventions, in order to  
237 ensure that these workers can continue to have access to safe and healthy workplaces, and not  
238 bear an undue burden during a public health emergency such as COVID-19.

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242 this analysis.

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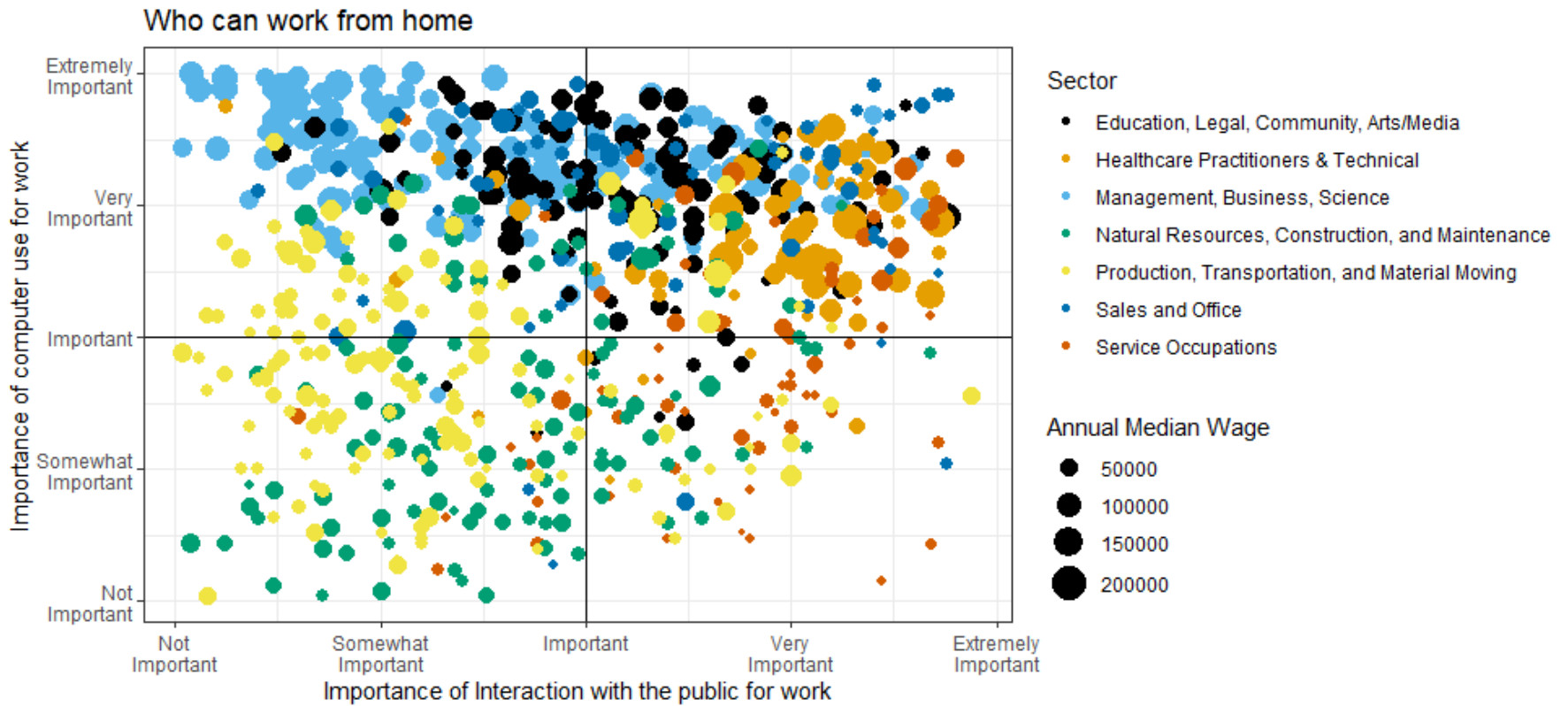
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344 **Figure 1:** Who can work from home? Workers in the top left quadrant are workers that are likely able to work from home, whereas  
345 those in the bottom right quadrant would not be able to work from home. Each point on the graph is weighted by the annual median  
346 wage for the occupation, and color-coded by broad occupational sector.

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349 **Table 1:** Distribution of median annual wages by quadrant, as shown in Figure 1

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Quadrant	Median Annual Wage			% workers	# workers	p*
	Mean (\$)	Median (\$)	Range (\$)			
Low computer, high public	34,258	32,040	(20,120--70,910)	19.5%	28,222,992	
Low computer, low public	40,068	38,190	(22,330--73,780)	19.6%	28,367,725	
High computer, high public	62,653	56,950	(22,260--201,100)	36.3%	52,538,184	
High computer, low public	66,196	62,710	(25,250--142,530)	24.6%	35,604,389	
All	55,518	48,690	(20,120--201,100)	100%	144,733,290	<0.0001

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352 \*One-way ANOVA of median annual wages by quadrant

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356 Table 2: Number and percent of workers in jobs that would be difficult to do from home (high public interaction, low computer use),  
 357 and easier to do from home (low public interaction, high computer use) by major (2-digit) standard occupational classification code  
 358 (SOC).

2-digit SOC	Median Annual Wage	total in SOC	Public interaction: High Computer Use: Low		Public Interaction: Low Computer Use: High	
			#	%	#	%
11 Management	\$104,240	7,616,650	--	--	2,434,670	32.0%
13 Business and Financial Operations	\$68,350	7,721,300	--	--	5,208,720	67.5%
15 Computer and Mathematical	\$86,340	4,384,300	--	--	4,382,270	99.9%
17 Architecture and Engineering	\$80,170	2,556,220	--	--	2,307,550	90.3%
19 Life, Physical, and Social Science	\$66,070	1,171,910	--	--	739,070	63.1%
21 Community and Social Services	\$44,960	2,171,820	48,520	2.2%	--	--
23 Legal	\$80,810	1,127,900	--	--	68,530	6.1%
25 Education, Training, and Library	\$49,700	8,779,780	243,080	2.8%	2,217,040	25.3%
27 Arts, Design, Entertainment, Sports, and Media	\$49,290	1,951,170	181,150	9.3%	825,260	42.3%
29 Healthcare Practitioners and Technical	\$66,440	8,646,730	162,290	1.9%	341,950	4.0%
31 Healthcare Support	\$29,740	4,117,450	960,630	23.3%	53,730	1.3%
33 Protective Service	\$40,640	3,437,410	1,402,780	40.8%	152,020	4.4%
35 Food Preparation and Serving Related	\$23,070	13,374,620	10,814,489	80.9%	--	--
37 Building and Grounds Cleaning and Maintenance	\$26,840	4,421,980	1,180,279	26.7%	--	--
39 Personal Care and Service	\$24,420	5,451,330	1,919,080	35.2%	--	--
41 Sales and Related	\$28,180	14,542,290	3,716,800	25.6%	1,824,250	12.5%
43 Office and Administrative Support	\$35,760	21,828,990	342,410	1.6%	9,949,290	45.6%
45 Farming, Fishing, and Forestry	\$25,380	480,130	37,780	7.9%	--	--
47 Construction and Extraction	\$46,010	5,962,640	1,269,520	21.3%	--	--
49 Installation, Maintenance, and Repair	\$45,540	5,628,880	396,800	7.0%	1,725,840	30.7%
51 Production	\$35,070	9,115,530	276,940	3.0%	1,925,250	21.1%
53 Transportation and Material Moving	\$32,730	10,244,260	4,113,300	40.2%	69,920	0.7%
All SOCs		144,733,290	28,222,992	19.5%	35,604,389	24.6%

