

What strategies can promote worker health and safety during the COVID-19 pandemic?

COVID-19 has affected millions of people in the United States and across the globe. As of April 2021, the World Health Organization (WHO) tallied more than 147 million confirmed cases of COVID-19, leading to more than 3 million deaths (WHO, 2021). Although vaccine campaigns provide the best mechanism for eradicating COVID-19, other public and occupational health measures will continue to be essential for limiting COVID-19 transmission. In particular, employers and workers will need to take precautions to support workplace health and safety until communities reach critical levels of vaccination (Aschwanden, 2021; Centers for Disease Control and Prevention [CDC], 2021d). Furthermore, some experts have hypothesized that, even with intensive vaccination efforts, COVID-19 is likely to continue to affect workers and firms (Aschwanden, 2021). Moreover, many scientists predict that pandemics like those caused by COVID-19 could become more common in the future (e.g., see Dodds, 2019).

The Clearinghouse for Labor Evaluation and Research ([CLEAR](#))² conducted this rapid evidence review to summarize the literature on strategies that can promote worker health and safety during the COVID-19 pandemic and in the future. The review sought to address the following three research questions:

1. What strategies have been used to promote worker health and safety during COVID-19?
2. What evidence exists on those strategies?
3. What are the implications of the strategies for workers?

The evidence presented here is based on CLEAR's rapid review of 41 peer-reviewed publications. These publications included eight causal studies, 22 descriptive studies (e.g., case studies, descriptive quantitative analyses, qualitative analyses, predictions based on mathematical models), and 18 other types of research publications (e.g., literature reviews, document reviews, and opinion pieces from subject matter experts).³

¹ This version includes literature published from January 1, 2007 to August 31, 2021. CLEAR continues to search for relevant literature and may update this synthesis as new research emerges.

² CLEAR's mission is to make research on labor topics more accessible to practitioners, policymakers, researchers, and the public to support evidence-informed decision-making. CLEAR does this by conducting systematic evidence reviews, summarizing individual studies of programs, and synthesizing research across individual evidence bases.

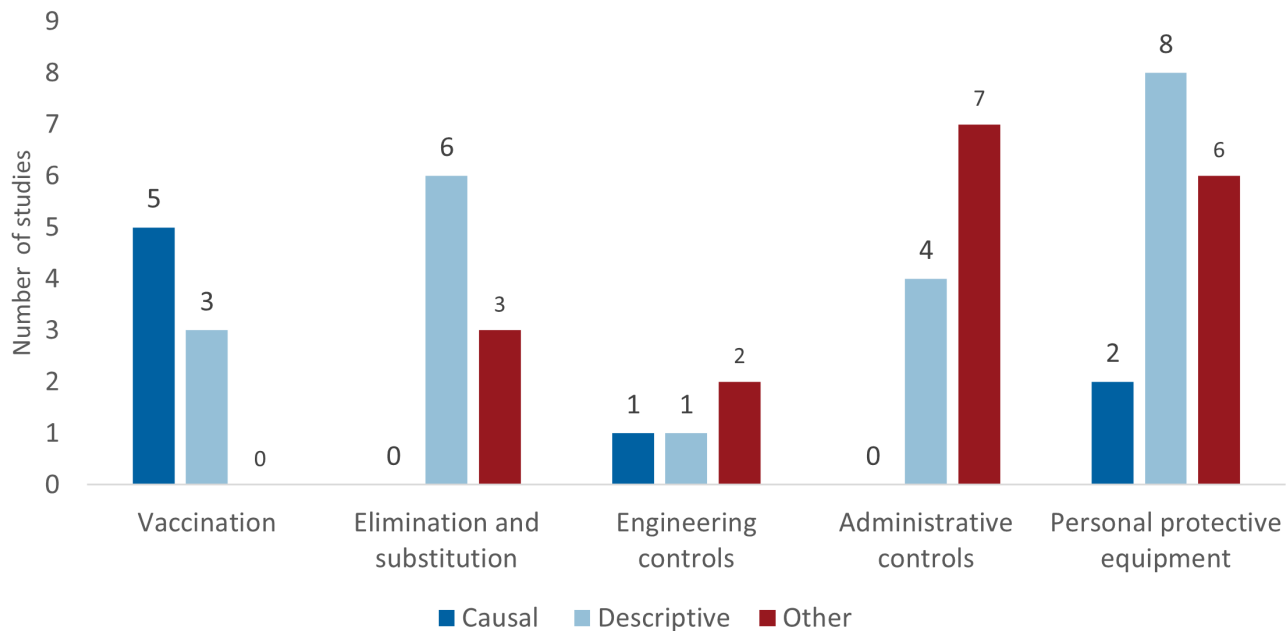
³ Some publications addressed more than one topic or included more than one type of analysis.

The review team classified strategies into five groups, adapted from the hierarchy of controls identified by CDC’s National Institute for Occupational Safety and Health (NIOSH, 2015):

1. Vaccination⁴
2. Elimination and substitution
3. Engineering controls
4. Administrative controls
5. Personal protective equipment (PPE)

Figure 1 shows the number of studies included in the rapid review, classified by strategy and type of research. A supplement to this synthesis provides citations with links to the publications, further information about study findings, and details about how CLEAR conducted this rapid review.

Figure 1. Types of studies by topic



Frameworks for understanding health and safety risks and mitigation strategies

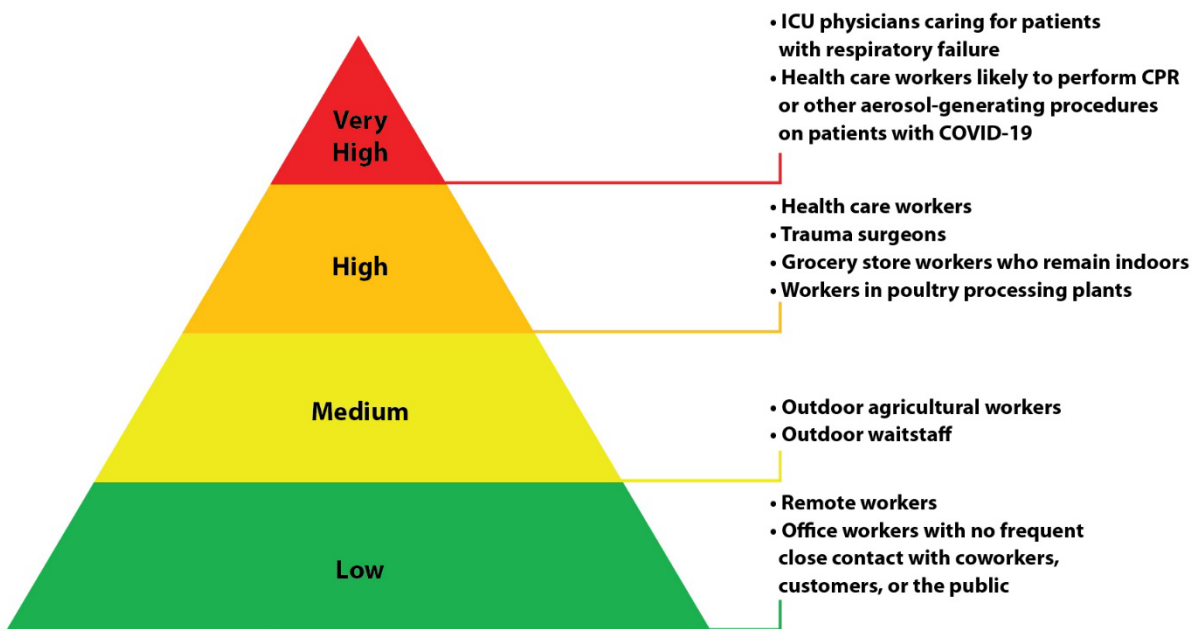
Given the range of workers, jobs, and mitigation strategies, several frameworks have been proposed to scaffold workplace responses to COVID-19. In particular, the Occupational Safety

⁴ NIOSH (2015) does not discuss vaccination, but it is an important mechanism for the prevention of workplace risks related to COVID-19.

and Health Administration (OSHA, 2020) provides a framework for understanding worker risks, and NIOSH (2015) provides a hierarchy of mechanisms for reducing these risks.

According to the occupational risk pyramid introduced by OSHA, job tasks can be divided into four exposure levels: low, medium, high, and very high risk (Figure 2). Low-exposure-risk jobs involve no contact with people known to have or suspected of having COVID-19. Medium-exposure-risk jobs include frequent or close contact with people who may be, but are not known to be, infected with COVID-19 or jobs in which workers have frequent or sustained outdoor or well-ventilated contact with coworkers or the public. High-exposure-risk jobs include exposure to known or suspected sources of COVID-19 or those in which there is frequent or sustained indoor or poorly ventilated contact with coworkers or the general public. Finally, very-high-exposure-risk jobs include extensive exposure to known or possible sources of COVID-19.

Figure 2. Occupational risk pyramid with examples of jobs in each category

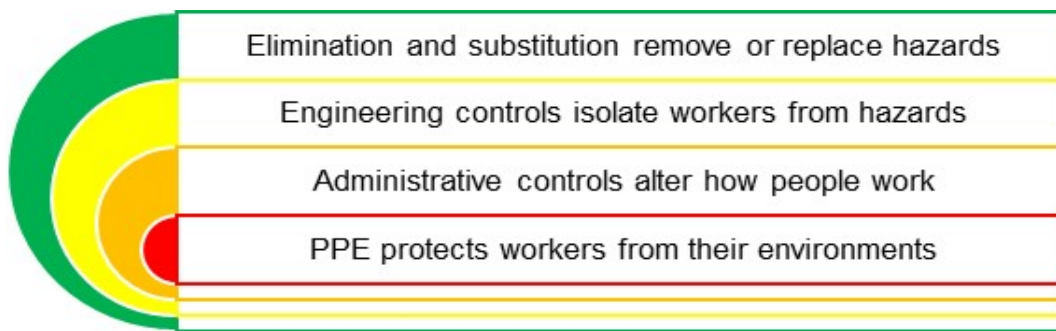


Source: Adapted from OSHA (2020).

NIOSH's hierarchy of controls for risk reduction categorizes strategies to address occupational health and safety risks (Figure 3). The most effective controls eliminate hazards altogether by removing pathogens from the environment or replacing the hazard with something less dangerous. When these strategies are not feasible or effective, engineering controls can help mitigate risks by controlling the hazard at the source, separating workers from risks. Examples of engineering controls used in response to COVID-19 include air filtration; improvements to

heating, ventilation, and air conditioning (HVAC) systems; ultraviolet germicidal irradiation; containment boxes; and physical barriers (Dehghani et al., 2020). Administrative controls and PPE can be used when it is not possible to isolate workers from hazards. Administrative controls alter how people work and include strategies such as screening and social distancing, whereas PPE (e.g., respirators and gloves) protects workers from their environment (Dehghani et al., 2020). Administrative controls and PPE are often the least expensive strategies to implement initially but can become costly over time. They also require significant effort on the part of workers and have proven to be less effective than the other measures (NIOSH, 2015).

Figure 3. Hierarchy of controls for risk reduction



Source: Adapted from NIOSH (2015).

Health and safety measures are especially important for protecting workers in essential jobs and industries.⁵ However, the definitions of essential workers, essential services, essential businesses, and essential industries vary greatly, even within the United States. For example, in defining essential activities:

- California includes both high-level industries, such as “health care/public health,” and individual job titles, such as “health care providers and caregivers” (State of California, 2021).
- Arizona describes types of businesses and organizations in which essential activities occur, for example, hospitals, pharmacies, and grocery stores (State of Arizona, 2020).
- Kansas includes specific types of activities, for example, protecting public safety or operating the government (State of Kansas, 2021).

⁵ See Table 1 in the supplement to this brief for examples of essential industries, businesses, services, and workers.

In special guidance released in 2020, CISA defined essential workers as those in the following sectors:

- Health care/public health
- Law enforcement, public safety, and other first responders
- Food and agriculture
- Energy
- Water and wastewater
- Transportation and logistics
- Public works and infrastructure support services
- Communications and information technology
- Other community- or government-based operations and essential functions (including education)
- Critical manufacturing
- Hazardous materials
- Financial services
- Chemical
- Defense industrial base
- Commercial facilities
- Residential/shelter facilities, housing and real estate, and related services
- Hygiene products and services

Despite this variation across some states, most states used guidance from the Cybersecurity and Infrastructure Security Agency (CISA), housed within the U.S. Department of Homeland Security, to identify essential activities. On May 19, 2020, CISA released revised guidance in response to the COVID-19 pandemic, defining a wide range of workers as essential (Krebs, 2020; see text box).

The essential workforce in the United States tends to have similar demographic and labor market characteristics to the overall workforce, although there are some differences (Blau et al., 2021; Kearney & Pardue, 2020; McCormack et al., 2020). McCormack et al. (2020) estimated that 40% of adults in the United States could be classified as essential workers, 46% of whom identified as female, 14% as Black, and 17% as Hispanic. About half of all essential workers had at least one key factor increasing their vulnerability to COVID-19, including low household income, living in a household with someone who lacked health insurance, and living in a household with someone aged 65 years or older. Thirteen percent of essential workers fell into multiple risk categories.

Essential “frontline” workers with jobs that must be done in person and close to others are more likely to be disadvantaged than other workers. These essential workers tend to be less educated and have lower wages compared to the overall workforce; they are also more likely to be immigrants, Black, Native American, or Hispanic (Blau et al., 2021; Dubay et al., 2020; Kearney & Pardue, 2020). Dubay et al. (2020) argue that essential frontline workers come from demographic groups that are more vulnerable to COVID-19 due to lower rates of health insurance coverage, higher rates of public transportation use, and a higher likelihood of living in a multigenerational household.

Research findings on strategies to promote worker health and safety

1. Vaccination

► **Vaccination is a crucial strategy for reducing the impacts of COVID-19.** As of April 2021, the Food and Drug Administration had issued emergency use authorizations to three vaccines,

making them available to prevent COVID-19 in the United States. At that time—prior to the mid-2021 emergence of new COVID-19 variants—the Pfizer-BioNTech vaccine had been shown to be 95% effective for preventing COVID-19, the Moderna vaccine had been shown to be 94% effective, and the Johnson & Johnson (Janssen) vaccine had been shown to be 67% effective (Baden et al., 2021; Polack et al., 2020; Sadoff et al., 2021).

▶ **Employers and work-based programs can boost vaccination rates.** Several studies have examined strategies to increase uptake of vaccines, including several that focus on workplace strategies. Nowalk et al. (2010) conducted a randomized controlled trial to examine the effects of an intervention offering employees a choice of vaccine types, providing incentives for vaccination, and increasing advertising on vaccine availability. The intervention increased the likelihood of vaccination by 40%. In another experiment, Milkman et al. (2011) found that prompts to write down the date and time an employee intended to receive a vaccine at an on-site clinic increased vaccination rates by 4.2 percentage points. Descriptive analyses of vaccination among health care workers further suggest vaccination rates are higher when employers provide free, on-site vaccinations; require workers to receive vaccines; send personal reminders; and publicize the firm’s vaccination rate (Yue et al., 2017, 2019). Verelst et al. (2021) further indicate that, by reducing worker absenteeism, work-based interventions to increase vaccination can have positive returns on investment for employers.

2. Elimination and substitution

▶ **For many people, working from home can eliminate workplace risks.** Remote or telework removes the possibility of exposure to COVID-19 in the workplace and has been used extensively during the pandemic. A survey of human resources departments indicates that about half of respondents’ companies had shifted the majority of employees to home-based work in April 2020 (Gartner, 2020). Respondents expected remote work to continue for the duration of the pandemic and to remain substantial thereafter. Bick et al. (2021) leveraged a national survey of workers to show that increased work from home persisted throughout 2020.

▶ **Remote work is not feasible for all jobs and workers, with women and low-income workers least able to use this strategy.** Individuals who must have face-to-face contact with customers cannot work from home. Based on an analysis of 900 job titles in Occupational Information Network (O*NET) data, Avdiu and Nayyar (2020) showed that face-to-face interaction varies greatly across jobs, with women and workers earning lower wages being more likely to hold jobs requiring face-to-face contact than others. Similarly, Holgersen et al. (2021) used a team of coders to classify tasks based on the extent to which they could be completed from home. The authors found that the jobs that were less conducive to working from home

were more commonly held by workers who faced barriers to employment (e.g., limited education). Using data on rates of working from home, Bick et al. (2021) further showed that individuals who were more educated, had higher income, were older, and had no children were more likely to work from home during the pandemic than others. In addition, research on staying home from work to avoid illness during influenza outbreaks suggests that self-employed workers and those with lower earnings are less likely than others to be able to stay home from work (Blake et al., 2010).

▶ **Working from home can negatively impact mental health and workplace productivity, but several strategies have been proposed to mitigate these consequences.** Working from home can lead to social isolation and worker loneliness and can make achieving work–life balance more difficult (De Pedro et al., 2021; Fragala et al., 2021; Kniffin et al., 2021; Schall & Chen, 2021). Several reviews of the literature have proposed strategies to mitigate these effects, including:

- Using supervisors or a “buddy system” (Fragala et al., 2021), or creating opportunities for nonwork interactions among coworkers, such as virtual lunches (Kniffin et al., 2021), to ensure workers maintain social contact with colleagues.
- Using rituals for transitioning between work and nonwork activities to manage boundaries and promote work–life balance (Kniffin et al., 2021).
- Having supervisors reflect on conflicts to work–life balance and actively assist workers in maintaining balance through conversations about needs, assistance with scheduling conflicts, and collaborative problem solving (Schall & Chen, 2021).
- Setting clear expectations about worker availability and use of mobile devices (Schall & Chen, 2021).

Remote work can also hinder productivity, especially for employees who typically work in co-located teams. Kniffin et al. (2021) make several recommendations to limit these effects based on a literature review. For teams adjusting to remote collaboration, the authors suggest that employees and leaders actively manage verbal and nonverbal communication to support effective business operations and avoid worker confusion. They also argue that organizations should carefully balance the need for and costs of monitoring workers at home and continue to actively invest in leaders’ skills, especially with respect to remotely managing staff.

3. Engineering controls

▶ **Engineering controls can reduce the risk of infection, but some may be relatively costly initially.** COVID-19 is an airborne disease and can remain present in indoor air for several hours

(Chin et al., 2020). Therefore, engineering controls that minimize or prevent workers' exposure to COVID-19 by changing the work environment could help prevent infections. Based on separate reviews of the literature, Dehghani et al. (2020) and Scantling-Birch et al. (2021) recommend workplaces use strategies such as increasing the number of air exchanges (e.g., by turning HVAC systems on before workers arrive and leaving systems on after workers leave), avoiding recirculating inadequately filtered air, increasing the use of outdoor air (e.g., by leaving windows open), using ultraviolet germicidal inactivation, and using high-efficiency air filters and portable air cleaners. Strategic use of either positive or negative room/building pressurization has also been recommended for industrial workplace settings (American Conference of Governmental Industrial Hygienists & American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021). Engineering controls such as high-efficiency air cleaners may be beneficial to deploy in conjunction with other interventions, such as universal masking, to reduce worker risk to a greater degree than would be possible with either approach alone (Lindsley et al., 2021). Dehghani et al. (2020) note that, due to high operation and maintenance costs, some engineering controls (e.g., ultraviolet germicidal irradiation) may be relatively expensive and are most appropriate for workplaces that are particularly high risk, such as hospitals. However, other engineering controls may actually provide a cost savings in the longer term over administrative controls or PPE, despite a higher initial cost (NIOSH, 2015). Some low-cost alternatives, such as opening windows, are appropriate for many workplaces.

► **Physical barriers may help maintain distance and limit worker interactions.** Both CDC (2021a) and OSHA (2021) recommend using physical barriers to support social distancing and to separate individual workers from other people. Such barriers may include plastic shielding, plexiglass, or flexible curtains. Based on analysis of infections at meat and poultry processing plants in 19 states, Dyal et al. (2020) argue that difficulties maintaining social distancing led to higher infection risk and recommend that firms install physical barriers when practical based on worker function. Dehghani et al. (2020) further suggest using physical barriers based on their review of the literature but caution that such structures might interfere with HVAC systems and have adverse effects.

Additional studies of this strategy—particularly of its effectiveness in real-world applications—are needed, and policy and recommendations will evolve to reflect new evidence. In one example, FDA (2020) amended its position on a specialized type of physical barrier—passive protective barrier enclosures—which had initially been identified as a strategy to improve health care provider safety when caring for hospitalized patients with COVID-19. Based on emerging evidence that passive enclosures may in some cases increase provider risk, the agency now

recommends that hospitals only use protective barrier enclosures that have mechanisms to establish negative pressure.

4. Administrative controls

▶ **Screening workers and others for symptoms of COVID-19 can reduce workplace infections.** Based on a review of the literature on the symptoms and incubation period of COVID-19, Fragala et al. (2021) recommend daily screening of workers for possible signs of illness, including temperature monitoring. The authors suggest that tracking could occur at home or at the workplace. Cinar et al. (2020) examined the literature on protecting oncology patients and health care workers from COVID-19. Based on that review, they recommend prescreening patients before they enter a health care facility and that providers use prescreening results to refer patients for regular care, telemedicine, evaluation, or emergent care. In addition, Grassly et al. (2020) further argue that health care workers should receive weekly polymerase chain reaction (PCR) testing for COVID-19, regardless of symptoms. They base this recommendation on results from a mathematical model, which predicts that weekly screening of high-risk workers could reduce the rate at which such workers transmit COVID-19 by 23%. Burrell et al. (2021) also stress the importance of both symptom checks and testing for employees based on a case study of a multinational manufacturing company.

▶ **Workplaces can promote social distancing through a wide range of practices.** Social distancing is associated with decreases in workplace infections but can be challenging in many cases (e.g., see Dyal et al., 2020). Kraus et al. (2020) provide several suggestions for supporting social distancing, including implementing occupancy limits for break rooms and staggering the timing of work breaks. Based on expert interviews, Elabd et al. (2020) found that using remote management technologies can help maintain social distancing in the construction industry. Additional strategies for achieving social distancing include modifying desk spacing, implementing visual reminders to maintain adequate distance, and employing alternative staffing models. For alternative staffing models, Mascha et al. (2020) propose an approach in which staff work seven 12-hour shifts every other week (and not at all during the other weeks). The authors used mathematical modeling to demonstrate that this work arrangement would reduce infection rates and staff shortages in health care settings. However, extended work shifts might also lead to poorer worker performance and mental health, reducing the potential benefits of this type of alternative staffing arrangement (e.g., see Van Zundert et al., 2020).

▶ **Contact tracing may be useful for controlling workplace infections.** When an outbreak occurs, effective contact tracing may help mitigate its effects. Based on a literature review, Fragala et al. (2021) suggest that employers proactively develop protocols to quickly notify

employees who might have been exposed to an individual with COVID-19. Such protocols should not reveal the identity of an infected colleague to maintain privacy and compliance with nondiscrimination requirements. A case study at an Australian farm (Franklin & O'Sullivan, 2020) exemplifies how contact tracing and workplace surveillance can help workers and firms. The business had implemented a workplace health management plan, which included monitoring worker health, increasing cleaning regimens, and segregating work areas. After an employee was diagnosed with COVID-19, all 180 workers at the farm were tested; the employer identified 29 close contacts with the infected individual and isolated them immediately. Staff with negative test results were able to quickly return to work, supporting continuity of business operations. Based on another case study, Burrell et al. (2021) emphasize that contact tracing as part of a multilevel workplace strategy can promote employee satisfaction and have positive return on investment.

► **Workplaces should promote hand hygiene and routine disinfecting.** Hand washing (or use of hand sanitizer as a secondary option) and routine disinfection of surfaces may reduce the spread of COVID-19. Based on a review of the literature, Scantling-Birch et al. (2021) recommend firms encourage handwashing among workers and use soap and water, alcohol-based disinfectants, bleach, or hydrogen peroxide to disinfect surfaces that might carry infections. Both Dehghani et al. (2020) and Scantling-Birch et al. (2021) further suggest the use of ultraviolet light to disinfect surfaces, although the latter note that there is less research on the effectiveness of this technology in mitigating the spread of COVID-19. Dyal et al. (2020) also argue that employers can prevent the spread of COVID-19 by supporting hand hygiene and cleaning and disinfecting surfaces regularly, although these measures are secondary compared to reducing aerosol/droplet exposure (CDC, 2021c).

5. Personal protective equipment

► **PPE provides important protection for workers.** Almost all protocols for infection control suggest using PPE when workers must physically interact with others (Dehghani et al., 2020; Scantling-Birch et al., 2021). In a large-scale, prospective study by Nguyen et al. (2020), access to adequate PPE was associated with reductions in COVID-19 infections among frontline health workers. In addition, Warren et al. (2020) argue, based on data from workers at COVID-19 testing sites, that masks typically used for surgical procedures (ASTM level 1), when combined with eye protection, gloves, and gowns, provide adequate protection for frontline health workers.

The research on reuse of PPE is mixed. Duncan et al. (2020) conducted an observational study of N95 respirator efficacy after repeat use. The study found that, if a worker is properly trained in using the respirator and has it expertly fitted, the device can remain effective even with extreme

use (up to 19 uses over 5 days). However, Nguyen et al. (2020) found that reusing PPE was associated with higher infection rates in health care settings. Based on a review of the literature, Garcia Godoy et al. (2021) also suggest that extended use, reuse, and decontamination of N95 respirators may reduce their effectiveness.

▶ **Different types of face coverings and respirators do not provide the same protection.**

Several studies indicate that different types of respirators and face masks have very different efficacy rates. Based on research from lab-based studies, Garcia Godoy et al. (2021) conclude that N95 respirators provide better protection than face coverings. A literature review by Scantling-Birch et al. (2021) summarizes research indicating that filtering facepiece respirators (such as N95 respirators) were more effective than surgical masks or reusable cotton masks in protecting users from COVID-19 and similar pathogens. Based on a systematic review, Hirschmann et al. (2020) further caution that readily available and typically used surgical supplies might not offer sufficient protection against COVID-19 for health care workers performing certain types of surgery.

▶ **Obtaining and effectively using PPE has posed a challenge for workers and firms, increasing workers' stress and anxiety.**

Several research studies document difficulties in obtaining PPE for essential workers early in the pandemic. For example, in Albano et al.'s (2020) survey of more than 2,000 Italian radiologists in April 2020, 70% reported their institutions had trouble obtaining and providing PPE, with the most pronounced issues in public and southern hospitals. An online survey of 1,055 German rescue and emergency medical workers also indicated that, although most workers received new PPE daily, face shields and the most effective types of filtering facepiece respirators were available to only about half of all workers (Friedrichson et al., 2020). The study authors estimated that 41% of workers were exposed to COVID-19 without adequate PPE. Another online survey, conducted in late March and early April 2020 with 936 medical workers in Latin America, indicated that some workers lacked access to disposable face masks, many lacked access to N95 respirators, and the majority lacked access to face shields (Delgado et al., 2020).

Lack of access to PPE is often worse for workers who are more vulnerable to COVID-19. Gaitens et al. (2021) argue, based on a literature review, that workers who are racial or ethnic minorities and workers who earn lower wages have less access to PPE than other essential workers. This is echoed by Hammonds et al. (2020), who note that low-wage workers are two to three times less likely to have access to PPE, with particularly acute shortages among people of color working in low-wage jobs.

Several barriers to use of PPE have also been noted. Davey et al. (2021) surveyed health care workers in the United Kingdom about perceived issues with consistently and correctly wearing PPE. Respondents reported that PPE could cause discomfort, heat-related issues (e.g., sweating, headaches, and fatigue), and impaired physical performance at work. Qualitative analysis of concerns by Australian health care workers also suggests that health care workers may need more guidance and training on effective use of PPE (Ananda-Rajah et al., 2020). A survey of 2,558 essential workers conducted in April and May 2020 also revealed that essential workers faced stress and often did not feel safe at work due to lack of PPE and training on how to use it (Hammonds et al., 2020). These gaps were also noted during the H1N1 outbreak of 2009–2010 (Beckman et al., 2013).

Where are the gaps in the research on strategies to promote worker health and safety during the COVID-19 pandemic?

- **Research should explore the effects of strategies to increase COVID-19 vaccine uptake.** Although much research has examined efforts to increase uptake of influenza and other vaccines, there may be unique challenges to encouraging uptake of the COVID-19 vaccine due to vaccine hesitancy (Aschwanden et al., 2021; Dror et al., 2020). Research should therefore explore strategies that employers and public health authorities could use to support vaccination against COVID-19.
- **There is a lack of causal research on strategies to promote mental health during social isolation.** The COVID-19 pandemic led to dramatic increases in working from home and a corresponding rise in social isolation (Bick et al., 2021; Venkatesh & Edirappuli, 2020). Although many strategies have been proposed to support worker mental health under these conditions, few causal studies have examined the effectiveness of these strategies.
- **More research is needed on health and safety for workers of color.** Black, Native American, and Hispanic workers were more likely than workers of other races/ethnicities to have essential jobs requiring face-to-face contact (Blau et al., 2021; Dubay et al., 2020; Kearney & Pardue, 2020). Research also suggests that these demographic groups are also less likely than others to have sufficient access to PPE (Gaitens et al., 2021). Future research could explore avenues for ensuring more equitable access to the equipment needed to keep workers safe. It is also worth acknowledging that gaps exist for positions involving lower pay and requiring less formal education more generally and, as such, may also warrant additional research.
- **Research is needed on strategies to reduce occupational violence associated with COVID-19.** A number of media sources have reported workers facing violence (both physical and verbal) in response to implementing and enforcing mask wearing, social distancing, and other policies (Porterfield, 2020; see also Hammonds et al., 2020). Health

care workers have also been targeted as potential carriers of COVID-19 (Vento et al., 2020). Research is needed on strategies to prevent and deescalate such conflicts.

Rapid Evidence Review Supplement: Citations and Further Information

This supplement to the rapid review, “What strategies can promote worker health and safety during the COVID-19 pandemic?” provides information on citations and brief study summaries for the evidence summarized in the rapid review. It also includes examples of essential industries, businesses, services, and workers (Table 1). The final section describes the approach used to create the rapid review.

CITATIONS AND STUDY SUMMARIES

This supplement presents the citations and summaries using the same organization as the rapid review. The subsections are as follows:

1. Vaccination
2. Elimination and substitution
3. Engineering controls
4. Administrative controls
5. Personal protective equipment (PPE)
6. Other citations supporting the synthesis

1. Vaccination

Baden, L. R., El Sahly, H. M., Essink, B., Kotloff, K., Frey, S., Novak, R., Diemert, D. Spector, S. A., Roupheal, N., Creech, C. B., McGettigan, J., Khetan, S., Segall, N., Solis, J., Brosz, A., Fierro, C., Schwartz, H., Neuzil, K., Corey, L., ... Zaks, T. (2021). Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. *New England Journal of Medicine*, 384(5), 403–416. <https://www.nejm.org/doi/full/10.1056/nejmoa2035389>

- Type of Research: Causal (randomized controlled trial)
- Summary: This study summarizes findings from the clinical trial of the Moderna **COVID-19** vaccine. The study team conducted a **randomized controlled trial** with more than 30,000 participants in the **United States**. Based on this trial, vaccine efficacy was estimated at 94%, with similar efficacy across subgroups defined by age, sex, race and ethnicity, and health risks.

Milkman, K. L., Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2011). Using implementation intentions prompts to enhance influenza vaccination rates. *Proceedings of the National Academy of Sciences*, 108(26), 10415–10420. <https://www.pnas.org/content/pnas/early/2011/06/03/1103170108.full.pdf>

- Type of Research: Causal (randomized controlled trial)

- Summary: This study summarizes findings from a **randomized controlled trial** testing two interventions designed to increase vaccination receipt at free, on-site clinics provided by a large firm. All employees received a reminder about the vaccine clinic. Individuals were randomly assigned to a control reminder group or one of two treatment reminder groups who were prompted to write down either the date they intended to get vaccinated or both the date and time they intended to get vaccinated. The prompt to write down the intended date only did not significantly increase vaccination rates; however, the prompt to write down both the date and time significantly increased vaccination rates from 33% to 37%.

Nowalk, M. P., Lin, C. J., Toback, S. L., Rousculp, M. D., Eby, C., Raymund, M., & Zimmerman, R. K. (2010). Improving influenza vaccination rates in the workplace: A randomized trial. *American Journal of Preventive Medicine*, 38(3), 237–246. <https://www.ajpmonline.org/article/S0749-3797%2809%2900852-6/fulltext>

- Type of Research: Causal (randomized controlled trial)
- Summary: This study describes findings from a **randomized controlled trial** conducted with 53 companies in the **United States**. Companies were assigned to one of three conditions: (1) a Choice condition, in which employees were offered the choice of injectable or intranasal influenza vaccines at an on-site vaccine provider; (2) a Choice Plus condition, in which vaccine advertising was increased, employees were offered a choice of injectable or intranasal vaccines at an on-site provider, and employees received a nominal incentive for receiving a vaccine; or (3) a control condition, in which employers advertised and provided vaccines as usual. Based on a hierarchical linear model, individuals in the Choice Plus condition were 40% more likely than individuals in the control condition to have received any influenza vaccine. The difference between the Choice and control groups was not statistically significant. The authors conclude that the combination of advertising, choice, and incentives was effective in increasing vaccination rates.

Polack, F. P., Thomas, S. J., Kitchin, N., Absalon, J., Gurtman, A., Lockhart, S., Perez, J. L., Marc, G. P., Moreira, E. D., Zerbini, C., Bailey, R., Swanson, K. A., Roychoudhury, S., Koury, K., Li, P., Kalina, W. V., Cooper, D., Frenck, R. W. Jr., Hammitt, L. L., ... Gruber, W.C. (2020). Safety and efficacy of the BNT162b2 mRNA Covid-19 vaccine. *New England Journal of Medicine*, 383(27), 2603–2615. <https://www.nejm.org/doi/full/10.1056/NEJMoa2034577>

- Type of Research: Causal (randomized controlled trial)
- Summary: This study summarizes findings from the clinical trial of the Pfizer-BioNTech **COVID-19** vaccine. The study team conducted a **randomized controlled trial** with more than 40,000 participants in the **United States, Germany, Turkey, Brazil, South Africa, and Argentina**. Based on this trial, vaccine efficacy was estimated at 95%, with similar efficacy

across subgroups defined by age, sex, race, ethnicity, body mass index, and medical conditions.

Sadoff, J., Gray, G., Vandebosch, A., Cárdenas, V., Shukarev, G., Grinsztejn, B., Goepfert, P. A., Truysers, C., Fennema, H., Spiessens, B., Offergeld, K., Scheper, G., Taylor, K. L., Robb, M. L., Treanor, J., Barouch, D. H., Stoddard, J., Ryser, M. F., Marovich, M. A., ... Douoguih, M. (2021). Safety and efficacy of single-dose Ad26. COV2. S vaccine against Covid-19. *New England Journal of Medicine*, 384, 2187–2201. <https://www.nejm.org/doi/full/10.1056/NEJMoa2101544>

- Type of Research: Causal (randomized controlled trial)
- Summary: This study summarizes findings from the clinical trial of the Johnson & Johnson (Janssen) **COVID-19** vaccine. The study team conducted a **randomized controlled trial** with 19,630 participants in the **United States, Argentina, Brazil, Chile, Colombia, Mexico, Peru, and South Africa**. Based on this trial, vaccine efficacy was estimated at 67%, with similar efficacy across subgroups defined by age, sex, race, ethnicity, and country. Vaccine efficacy in preventing severe infections was higher: 85%.

Verelst, F., Beutels, P., Hens, N., & Willem, L. (2021). Workplace influenza vaccination to reduce employee absenteeism: An economic analysis from the employers' perspective. *Vaccine*, 39(14), 2005–2015. <https://www.sciencedirect.com/science/article/pii/S0264410X21001687>

- Type of Research: Descriptive (mathematical modeling)
- Summary: This study discusses the results of a mathematical model of influenza during the **2011–2012 to 2017–2018 influenza seasons in Belgium**. The authors used simulations to assess the impact of employer provision of free on-site influenza vaccines. The authors found that the simulated policy would have averted up to 355,000 cases of influenza, including 150,000 cases among employed people and 205,000 additional cases. Economic analysis further revealed that the intervention was typically, though not always, cost effective for employers.

Yue, X., Black, C., Ball, S., Donahue, S., De Perio, M. A., Laney, A. S., & Greby, S. (2017). Workplace interventions associated with influenza vaccination coverage among health care personnel in ambulatory care settings during the 2013-2014 and 2014-2015 influenza seasons. *American Journal of Infection Control*, 45(11), 1243–1248. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6005645/>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined predictors of influenza vaccination among health care workers in long-term care facilities during the **2013–2014 and 2014–2015 influenza seasons**. The authors conducted **online surveys** of health care workers in April 2014 and April 2015. Rates of vaccination were significantly higher when employers provided on-site vaccination

opportunities and sent employees personal reminders. Requirements to sign a waiver or wear a visible sign (such as a badge) if not vaccinated, financial incentives or rewards, publication of vaccine coverage rates, and publication of risks and benefits of vaccination were not consistently associated with vaccination rates across methods for estimating associations.

Yue, X., Black, C., Ball, S., Donahue, S., de Perio, M. A., Laney, A. S., & Greby, S. (2019). Workplace interventions and vaccination-related attitudes associated with influenza vaccination coverage among healthcare personnel working in long-term care facilities, 2015–2016 influenza season. *Journal of the American Medical Directors Association*, 20(6), 718–724. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6538419/>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined predictors of influenza vaccination among health care workers in long-term care facilities during the **2015–2016 influenza season**. The authors conducted an **online survey** of 2,258 health care workers in April 2016. Rates of vaccination were significantly higher when employers provided on-site vaccination opportunities, publicized vaccination coverage rates, and implemented vaccination requirements. Personal reminders, publication of vaccine risks and benefits, and requirements to sign a waiver if not vaccinated were not significantly associated with vaccination rates.

2. Elimination and substitution

Avdiu, B., & Nayyar, G. (2020). When face-to-face interactions become an occupational hazard: Jobs in the time of COVID-19. *Economics Letters*, 197, 109648. <https://doi.org/10.1016/j.econlet.2020.109648>

- Type of Research: Descriptive (quantitative)
- Summary: This study used data on 900 job titles from the **Occupational Information Network** to examine variation in the importance of face-to-face contact across jobs. The authors found that face-to-face work varies by industry and across different types of workers. In particular, jobs with intensive face-to-face interaction tend to have lower wages, and a larger share of women than men hold face-to-face intensive jobs.

Bick, A., Blandin, A., & Mertens, K. (2021). *Work from home before and after the COVID-19 outbreak*. Federal Reserve Bank of Dallas. <https://www.dallasfed.org/-/media/documents/research/papers/2020/wp2017r2.pdf>

- Type of Research: Descriptive (quantitative)
- Summary: The study authors used data from the **Real-Time Population Survey**, an online nationwide survey to track workers' habits and to examine trends in working from home before, during, and after the **COVID-19 pandemic**. In May 2020, 31% of the workforce worked from home full or part time, compared with 8% in February 2020. This share remained

at 21% in December 2020. People with more education and higher incomes, older people, and people without children were more likely to shift their employment status to work from home during the pandemic.

Blake, K. D., Blendon, R. J., & Viswanath, K. (2010). Employment and compliance with pandemic influenza mitigation recommendations. *Emerging Infectious Diseases*, 16(2), 212–218. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2958001/>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined the extent to which employees in the **United States** might not comply with social distancing recommendations due to concerns about job insecurity and financial difficulty. The authors conducted regression analyses using data from the **2006 Harvard School of Public Health Pandemic Influenza Survey**. Being unable to work from home, not having paid sick leave, and employee income level were associated with workers' ability to comply with social distancing recommendations during influenza outbreaks.

De Pedro, M. M., Fernández-Valera, M. M., García-Izquierdo, M., & Soler-Sánchez, M. I. (2021). Burnout, psychological capital and health during COVID-19 social isolation: A longitudinal analysis. *International Journal of Environmental Research and Public Health*, 18(3), 1–11. <https://www.mdpi.com/1660-4601/18/3/1064>

- Type of Research: Descriptive (quantitative)
- Summary: This study assessed the influence of isolation due to the **COVID-19 pandemic** on workers' self-reported levels of health and psychological capital. The authors delivered **two surveys** to individuals in **Spain**, the first in December 2019 and the second in April 2020. From the surveys, the authors conclude that employees' perceptions of their health and psychological capital have significantly worsened during mandatory confinement. Burnout and age were correlated with employees' perceptions of physical and mental health.

Gartner. (2020). *Gartner HR survey reveals 41% of employees likely to work remotely at least some of the time post coronavirus pandemic* [Press release]. <https://www.gartner.com/en/newsroom/press-releases/2020-04-14-gartner-hr-survey-reveals-41--of-employees-likely-to->

- Type of Research: Descriptive (quantitative)
- Summary: This press release discusses findings from a **survey of 229 human resources professionals** conducted to assess work-from-home trends during the **COVID-19 pandemic**. Almost half of all survey respondents indicated that 81% or more of employees in their companies were working remotely in April 2020. Moreover, the survey indicated that companies expect remote work to be higher after the COVID-19 pandemic than before. The

authors estimated that 41% of employees will continue to work remotely, at least in part, after the pandemic.

Holgerson, H., Jia, Z., & Svenkerud, S. (2021). Who and how many can work from home? Evidence from task descriptions. *Journal for Labour Market Research*, 55(1), 1–13. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7917536/>

- Type of Research: Descriptive (quantitative)
- Summary: This study assessed which jobs are most easily performed from home and who works in those jobs. The authors asked workers on **Amazon Mechanical Turk** to evaluate if jobs from the International Standard Classification of Occupations 2008 (ISCO-08) could be performed at home. The authors then mapped these jobs to workers in **Norway**. The authors found that about 38% of Norwegian workers have jobs that could be performed from home and that workers facing barriers to employment (including those who are young, less educated, single parents, or migrants) are less likely than other workers to have jobs that could be performed at home.

Fragala, M. S., Goldberg, Z. N., & Goldberg S. E. (2021). Return to work: Managing employee population health during the COVID-19 pandemic. *Population Health Management*, 24(S1), S3–S15. <https://doi.org/10.1089/pop.2020.0261>

- Type of Research: Other (literature review)
- Summary: This study provides perspectives for self-insured employers for managing population health during the **COVID-19 pandemic**. The authors reviewed evidence-based best practices for preventing COVID-19 spread in the workplace. Possible interventions discussed include face mask use, symptoms screening, diagnostic testing, population-based testing, polymerase chain reaction (PCR) testing, antigen testing, antibody testing, home specimen collection for diagnostic testing, vaccination, clinical treatment, workplace surveillance, contact tracing, monitoring workplace metrics, and having an integrated command center.

Kniffin, K. M., Narayanan, J., Anseel, F., Antonakis, J., Ashford, S. P., Bakker, A. B., Bamberger, P., Bapuji, H., Bhawe, D. P., Choi, V. K., Creary, S. J., Demerouti, E., Flynn, F. J., Gelfand, M. J., Greer, L. L., Johns, G., Keesbir, S., Klein, P. G., Lee, S. Y., ... Vugt, M. V. (2021). COVID-19 and the workplace: Implications, issues, and insights for future research and action. *American Psychologist*, 76(1), 63. <https://psycnet.apa.org/record/2020-58612-001>

- Type of Research: Other (literature review)
- Summary: This article is a literature review focused on changes in work practices due to the **COVID-19 pandemic**, such as working from home and virtual teamwork, and the implications of these changes for workers. Based on their review, the authors suggest a wide range of

strategies to help workers and firms. Recommendations include (1) training leaders to facilitate job shifts so that employees can better cope with uncertain job demands, (2) not incentivizing employees to work through illness and having leaders set an example by not working when ill, (3) investing in technologies designed to identify risky behaviors and monitor remote workers while remaining cognizant of privacy concerns, and (4) actively intervening to help workers maintain work–life balance and mental health.

Schall, M. C., Jr., & Chen, P. (2021). Evidence-based strategies for improving occupational safety and health among teleworkers during and after the coronavirus pandemic. *Human Factors*. <https://journals.sagepub.com/doi/pdf/10.1177/0018720820984583>

- Type of Research: Other (literature review)
- Summary: This article is a literature review on evidence-based strategies for improving occupational safety, health, and well-being among teleworkers during the **COVID-19 pandemic**. The literature supports strategies aimed at increasing worker motivation to engage in safe and healthy behaviors by enhancing safety leadership, managing role boundaries to reduce risks, and redesigning work to strengthen interpersonal interactions, interdependence, and workers' initiation.

3. Engineering controls

Dehghani, F., Omid, F., Yousefinejad, S., & Taheri, E. (2020). The hierarchy of preventive measures to protect workers against the COVID-19 pandemic: A review. *Work*, 67(4), 771–777. <https://content.iospress.com/articles/work/wor203330>

- Type of Research: Other (literature review)
- Summary: This study examined literature on current practices to limit the spread of **COVID-19** in workplaces. The authors reviewed and discussed current worker protections against COVID-19, including PPE, administrative controls, and engineering controls. The study authors recommend using various control methods to prevent the spread of COVID-19 in the workplace. The authors also note that workplaces should determine which controls to use based on risk of exposure and argue that relying solely on one control measure is likely not sufficient to prevent viral spread, suggesting that workplaces should use several methods together.

Dyal, J. W., Grant, M. P., Broadwater, K., Bjork, A., Waltenburg, M. A., Gibbins, J. D., Hale, C., Silver, M., Fischer, M., Steinberg, J., Basler, C. A., Jacobs, J. R., Kennedy, E. D., Tomasi, S., Trout, D., Hornsby-Myers, J., Oussayef, N. L., Delaney, L. J., Patel, K., ... Honein, M. A. (2020). COVID-19 among workers in meat and poultry processing facilities - 19 States, April 2020. *Morbidity and Mortality Weekly Report*, 69(18), 557–561. https://www.cdc.gov/mmwr/volumes/69/wr/mm6918e3.htm?s_cid=mm6918e3_w

- Type of Research: Descriptive (qualitative and quantitative)
- Summary: This study examined **COVID-19** cases and preventive measures for workers in meat and poultry processing plants in **19 states**. The study authors examined **qualitative data gathered during on-site and remote assessments** and **aggregated quantitative data submitted by states to the Centers for Disease Control and Prevention (CDC)**. Across 115 meat and poultry processing facilities, 4,913 cases of COVID-19 were reported from April 9–27 (representing 3% of workers), resulting in 20 deaths. The authors found that facilities faced barriers to maintaining adequate distance between workers. They also note that workers might fail to stay home when ill due to socioeconomic challenges. The authors recommend that facilities improve physical distancing, install barriers when feasible, support hand hygiene, and clean and disinfect surfaces regularly to prevent the spread of COVID-19. They also suggest that providing workers with medical leave and educational materials in multiple languages could reduce COVID-19 in these settings.

Lindsley, W. G., Derk, R. C., Coyle, J. P., Martin, S. B., Mead, K. R., Blachere, F. M., Beezhold, D., H., Brooks, J. T., Boots, T., & Noti, J. D. (2021). Efficacy of portable air cleaners and masking for reducing indoor exposure to simulated exhaled SARS-CoV-2 Aerosols—United States. *Morbidity and Mortality Weekly Report*, 70(27), 972–976.
https://www.cdc.gov/mmwr/volumes/70/wr/mm7027e1.htm?s_cid=mm7027e1_w

- Type of Research: Other (other nonexperimental design)
- Summary: This article describes the processes and outcomes of a simulation of the use of **high-efficiency air cleaners and universal masking** to reduce exposure to aerosols. The study team tested these interventions individually and in combination in a setting simulating a meeting in a conference room involving one infected participant and three uninfected participants. Use of high-efficiency air cleaners alone reduced exposure up to 65%, depending on the placement of the filters; universal masking alone reduced exposure by 72%; and the combination of the two interventions reduced exposure by up to 90%.

Scantling-Birch, Y., Newton, R., Naveed, H., Rajak, S., & Bhutta, M. F. (2021). Healthcare worker protection against epidemic viral respiratory disease. *Postgraduate Medical Journal*.
<http://dx.doi.org/10.1136/postgradmedj-2020-139555>

- Type of Research: Other (literature review)
- Summary: The authors conducted a literature review on risk protection for health care workers during a respiratory epidemic or pandemic, such as the **COVID-19 pandemic**. The article summarizes a wide range of evidence and approaches, including substituting higher risk procedures with lower risk procedures, using environment and engineering controls, changing administrative policies, and increasing the availability of PPE.

4. Administrative controls

Burrell, G., & Nundy, S. (2021). A return-to-work program for Covid-19 for a multistate essential business. *NEJM Catalyst Innovations in Care Delivery*.
<https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0642>

- Type of Research: Other (case study)
- Summary: The study examined employees' satisfaction with a large health care advocacy company's **COVID-19** containment strategy. The company implemented a variety of measures, including contact tracing, symptom checks, virtual care and testing, return-to-work verification, and other methods. Results of the survey showed high employee engagement (80%) and satisfaction (92%), as well as a positive return on investment. Barriers to implementation included navigating changing health recommendations and fostering employee buy-in and trust.

Cinar, P., Kubal, T., Freifeld, A., Mishra, A., Shulman, L., Bachman, J., Fonseca, R., Uronis, H., Klemanski, D., Slusser, K., Lunning, M., & Liu, C. (2020). Safety at the time of the COVID-19 pandemic: How to keep our oncology patients and healthcare workers safe. *Journal of the National Comprehensive Cancer Network*, 18(5), 504–509.
<https://doi.org/10.6004/jnccn.2020.7572>

- Type of Research: Other (literature review)
- Summary: This study reviewed literature on mitigating the spread of **COVID-19** while caring for cancer patients, who are at a heightened risk for severe illness from the virus. Strategies for controlling the spread of the virus to protect cancer patients include conducting symptom screenings, limiting exposure to other people, using telemedicine, and limiting elective procedures. The review further emphasizes planning care in the safest manner possible, continuing to provide high-quality care, monitoring and testing health care workers, and communicating with family members on how to behave safely.

Dehghani, F., Omid, F., Yousefinejad, S., & Taheri, E. (2020). See description in Section 3.

Dyal, J. W., Grant, M. P., Broadwater, K., Bjork, A., Waltenburg, M. A., Gibbins, J. D., Hale, C., Silver, M., Fischer, M., Steinberg, J., Basler, C. A., Jacobs, J. R., Kennedy, E. D., Tomasi, S., Trout, D., Hornsby-Myers, J., Oussayef, N. L., Delaney, L. J., Patel, K., ... Honein, M. A. (2020). See description in Section 3.

Elabd, N. M., Mansour, Y. M., & Khodier, L. M. (2020). Social distancing in construction: Investigating the role of technologies in supporting remote management. *Journal of Engineering and Applied Science*, 67(8), 2073–2091.

- Type of Research: Descriptive (qualitative)

- Summary: This study examined remote management strategies for construction projects. The researchers conducted **interviews with experts** to determine the risks and benefits of remote management technologies during the **COVID-19 pandemic**. The study found that using remote management technologies can help promote social distancing and overcome some pandemic-related challenges. The study authors further argue that integrative remote management technologies are useful for tracking progress, maintaining social distancing, monitoring worksites, avoiding project delays, and keeping workers safe.

Fragala, M. S., Goldberg, Z. N., & Goldberg, S. E. (2021). See description in Section 1.

Franklin, R. C., & O'Sullivan, F. (2020). Horticulture in Queensland Australia, COVID-19 response. It hasn't all been bad on reflection. *Journal of Agromedicine*, 25(4), 402–408. <https://doi.org/10.1080/1059924X.2020.1815620>

- Type of Research: Other (case studies)
- Summary: This study examined how the agriculture industry in **Queensland, Australia**, has responded to the **COVID-19 pandemic** and related government directives. The researchers examined two case studies on this topic. The case studies showed that agriculture in Queensland has been generally safe, remained operable, and adapted well to changing conditions as a result of COVID-19. The authors further emphasize the importance of collaboration between industry and government. Broader effects of COVID-19–related policies include improved sanitation and better knowledge of seasonal workers' needs.

Grassly, N. C., Pons-Salort, M., Parker, E. P., White, P. J., & Ferguson, N. M. (2020). Comparison of molecular testing strategies for COVID-19 control: A mathematical modelling study. *The Lancet Infectious Diseases*, 20(12), 1381–1389.

- Type of Research: Descriptive (mathematical modeling)
- Summary: This study discusses the results of a mathematical model of **COVID-19** transmission and uses it to assess the efficacy of different testing strategies. The model suggests that self-isolation among individuals with COVID-19 symptoms would reduce the spread of COVID-19 by 47%. The model also predicts that PCR testing among symptomatic individuals would reduce the spread of COVID-19 but also reduce the efficacy of self-isolation (because some test results would be false negatives). Further, the model indicates that weekly PCR testing of health care workers could reduce these workers' contribution to the spread of COVID-19 by 23%. The authors conclude that PCR testing can be an important strategy for reducing COVID-19 transmission.

Kraus, A., Awoniyi, O., AlMalki, Y., Bardeesi, A. S. A., Edwards, B., AlHajjaj, F., Alossaimi, B., Benham, T., Bortolin, M., Cattamanichi, S., Court, M., Groves, J., Hernandez, A., Issa, F., Macgregor-Skinner, G., Manners, P., Molloy, M., Romney, D., Voskanyan, A., ... Ciottone, G. (2020). Practical solutions for healthcare worker protection during the COVID-19 pandemic response in the ambulatory,

emergency, and inpatient settings. *Journal of Occupational and Environmental Medicine*, 62(11), e616–e624.

https://journals.lww.com/joem/Fulltext/2020/11000/Practical_Solutions_for_Healthcare_Worker.16.aspx

- Type of Research: Other (subject matter expert opinion piece)
- Summary: In this article, the authors provide guidance on worker protection strategies relevant to the **COVID-19 pandemic** by using the Systems, Space, Staff, and Stuff paradigm of disaster management and the Hierarchy of Controls framework from CDC. The authors recommend social distancing measures, such as implementing occupancy limits for break rooms and staggering workers' breaks, and cleaning common areas more frequently. The authors also discuss methods of decontaminating N95 respirators to increase availability during shortages.

Mascha, E. J., Schober, P., Schefold, J. C., Stueber, F., & Luedi, M. M. (2020). Staffing with disease-based epidemiologic indices may reduce shortage of intensive care unit staff during the COVID-19 pandemic. *Anesthesia and Analgesia*, 131(1), 24–30.
<https://dx.doi.org/10.1213%2FANE.0000000000004849>

- Type of Research: Descriptive (mathematical modeling)
- Summary: The study establishes a model for staffing at health care institutions that optimizes the number of staff and reduces staff shortages during the **COVID-19 pandemic**. The researchers constructed a mathematical model for pandemic staffing assuming a 2:1 patient-to-staff ratio, 40-bed intensive care unit, and 12-hour shifts every day of every other week. Modeling assumed probabilities of infection of 10%, 25%, or 40%. The model showed that the proposed pandemic staffing model significantly reduced workforce shortages, with the effect increasing with the probability of infection.

Scantling-Birch, Y., Newton, R., Naveed, H., Rajak, S., & Bhutta, M. F. (2021). See description in Section 3.

5. Personal protective equipment

Albano, D., Bruno, A., Bruno, F., Calandri, M., Caruso, D., Clemente, A., Coppolino, P., Cozzi, D., De Robertis, R., Gentili, F., Grazzini, I., Jannone, M. L., Liguori, C., Natella, R., Pace, G., Posa, A., Scalise, P., Accarino, B., Bibbolino, C., ... Messina, C. (2020). Impact of coronavirus disease 2019 (COVID-19) emergency on Italian radiologists: A national survey. *European Radiology*, 30(12), 6635–6644.
<https://link.springer.com/article/10.1007/s00330-020-07046-7>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined the impact of **COVID-19** on **Italian** radiology departments. Researchers distributed a **25-question survey** in April 2020 about how COVID-19 impacted the safety and organization of daily activities in Italian radiology departments. Many workers

reported having performed at least one diagnostic or interventional procedure on patients and a reduction in elective imaging volume. Overall, 70% of workers reported their institution had trouble getting PPE, and 30% reported having been given a PCR COVID-19 test. In addition, 20% of workers reported being redeployed to provide COVID-19 clinical services.

Ananda-Rajah, M., Veness, B., Berkovic, D., Parker, C., Kelly, G., & Ayton, D. (2020). Hearing the voices of Australian healthcare workers during the COVID-19 pandemic. *BMJ Leader*. <https://doi.org/10.1101/2020.09.25.20197061>

- Type of Research: Descriptive (qualitative)
- Summary: This study sought to uncover the working concerns and lived experiences of **Australian** health care workers during the **COVID-19 pandemic**. The researchers distributed an open letter by email to 23,000 health care workers that prompted free-text response about concerns and experiences. Key themes included workplace health/safety standards, PPE availability and use, issues with workplace culture, self-reported COVID-19 infections, and moral injury (i.e., a violation of an individual's moral or ethical code that results in psychological distress).

Beckman, S., Materna, B., Goldmacher, S., Zipprich, J., D'Alessandro, M., Novak, D., & Harrison, R. (2013). Evaluation of respiratory protection programs and practices in California hospitals during the 2009-2010 H1N1 influenza pandemic. *American Journal of Infection Control*, 41(11), 1024–1031. <https://doi.org/10.1016/j.ajic.2013.05.006>

- Type of Research: Descriptive (quantitative) and other (document review)
- Summary: This study sought to determine **California** health care workers' knowledge of protection measures against respiratory viruses in light of the H1N1 influenza outbreak. The researchers conducted **on-site evaluations and interviews** with managers and health care workers at 16 hospitals. They found that all hospitals had implemented a minimum standard of having staff use an N95 respirator when working with a patient suspected of having the H1N1 virus. Almost all health care workers also reported they would wear at least an N95 respirator when working in close contact with a patient suspected of being infected with H1N1. However, review of **written records** at the hospitals indicated deficiencies in recordkeeping, program administration, program evaluation, employee training, and fit testing procedures.

Davey, S. L., Lee, B. J., Robbins, T., Randeva, H., & Thake, C. D. (2021). Heat stress and PPE during COVID-19: Impact on healthcare workers' performance, safety and well-being in NHS settings. *Journal of Hospital Infection*, 108, 185–188. <https://doi.org/10.1016/j.jhin.2020.11.027>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined the effect of heat stress from wearing PPE on health care

worker performance. The researchers conducted a **survey of health care workers** in the **United Kingdom** who were required to wear PPE during the **COVID-19 pandemic** to evaluate perceived levels of heat stress and its effects. Respondents reported experiencing symptoms of heat stress and reduced performance. A majority of respondents said that wearing PPE made their job more difficult.

Dehghani, F., Omid, F., Yousefinejad, S., & Taheri E. (2020). See description in Section 3.

Delgado, D., Quintana, F. W., Perez, G., Liprandi, A. S., Ponte-Negretti, C., Mendoza, I., & Baranchuk, A. (2020). Personal safety during the Covid-19 pandemic: Realities and perspectives of healthcare workers in Latin America. *International Journal of Environmental Research and Public Health*, 17(8), 2798. <https://doi.org/10.3390/ijerph17082798>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined perceptions of personal safety among health care workers in **Latin America** during the **COVID-19 pandemic**. The researchers distributed an **online survey** in late March and early April 2020 to 936 medical workers. The survey showed that workers had access to equipment including hand gel (95%), disposable gloves (91%), disposable gowns (67%), disposable surgical masks (84%), N95 masks (56%), and facial protective shields (33%). Workers expressed concerns about limited human resources support, physical protection, and support from public health authorities.

Duncan, S., Bodurtha, P., Bourgeois, C., Dickson, E., Jensen, C., & Naqvi, S. (2020). The impact of extreme reuse and extended wear conditions on protection provided by a surgical-style N95 filtering facepiece respirator. *Journal of Occupational and Environmental Hygiene*, 17(11–12), 546–559. <https://oeh.tandfonline.com/doi/pdf/10.1080/15459624.2020.1829633>

- Type of Research: Causal (comparison group)
- Summary: This study examined the effect of extreme reuse of N95 respirators on protective ability. The researchers subjected N95 respirators to up to 19 uses over 5 days and measured protective ability at regular intervals using sensors. Seven subjects reusing masks were compared with a single control subject. The study found that, if a worker is properly trained in using the respirator and has it expertly fitted, it can remain effective under extreme use conditions. The authors conclude that issues with hygiene and straps breaking are more likely to limit reuse than protective ability.

Friedrichson, B., Lotz, G., Naujoks, F., Zacharowski, K., & Piekarski, F. (2020). Health and personal safety at work during the SARS-CoV-2 pandemic. A Germany-wide survey of the emergency medical and rescue services. *Anesthesiologie Und Intensivmedizin*, 61(7–8), 295–301. <https://covid19.elsevierpure.com/en/publications/health-and-personal-safety-at-work-during-the-sars-cov-2-pandemic>

- Type of Research: Descriptive (quantitative)

- Summary: This study sought to determine how emergency physicians and rescue workers perceived their personal security during the **COVID-19 pandemic**, the personal protective measures implemented, and worker risk of severe illness from COVID-19. The researchers administered an **online survey** to 1,055 **German** rescue and emergency personnel. The majority of respondents (60%) rated perceived personal security as good, but 54% of respondents reported having a medical condition that could lead to more severe illness from COVID-19. Most workers received new PPE daily, but face shields and the most effective types of respirators were lacking, with only 48% and 52% of respondents reporting having access to these, respectively. The authors also estimated that 41% of emergency personnel were exposed to COVID-19 without adequate protection.

Gaitens, J., Condon, M., Fernandes, E., & McDiarmid, M. (2021). Covid-19 and essential workers: A narrative review of health outcomes and moral injury. *International Journal of Environmental Research and Public Health*, 18(4), 1–16. <https://doi.org/10.3390/ijerph18041446>

- Type of Research: Other (literature review)
- Summary: This study examined health outcomes and contributing factors to illness among essential workers who were not in the health care industry during the **COVID-19 pandemic**. The researchers reviewed 42 peer-reviewed and gray literature articles on these topics and compiled the results. Marginalized populations were at a greater risk of moral injury from work-related conditions, such as lack of access to PPE from their employer. The authors conclude that ethically and legally requiring employers to take safety precautions can have benefits for workers, employers, and communities.

Garcia Godoy, L. R., Jones, A. E., Anderson, T. N., Fisher, C. L., Seeley, K. M. L., Beeson, E. A., Zane, H. K., Peterson, J. W., & Sullivan, P. D. (2020). Facial protection for healthcare workers during pandemics: A scoping review. *BMJ Global Health*, 5(5), 1–9. <https://gh.bmj.com/content/5/5/e002553.abstract>

- Type of Research: Other (literature review)
- Summary: This study reviewed literature related to medical-grade facial protection for health care workers, including safety and efficacy of decontamination practices and alternative strategies in the event of a PPE shortage. The researchers conducted a literature review of 67 PubMed and gray literature articles, then synthesized findings from the studies. N95 respirators provided better protection than other face coverings (such as surgical masks or reusable cloth masks) in lab settings, which may mean better protection in the workplace. The authors conclude that extended use, reuse, and decontamination of N95 respirators may result in reduced protections, and little evidence suggests improvised masks or reused masks should be used when proper medical-grade PPE is unavailable.

Hammonds, C., Kerrissey, J., & Tomaskovic-Devey, D. (2020). *Stressed, unsafe, and insecure: Essential workers need a new, new deal*. UMass Amherst Labor Center. <https://www.umass.edu/employmentequity/stressed-unsafe-and-insecure-essential-workers-need-new-new-deal>

- Type of Research: Descriptive (quantitative)
- Summary: This study summarizes findings from the **Essential Worker Survey**, which asked more than 2,500 essential workers about their experiences with **COVID-19** in April and May 2020. Sixty percent of respondents did not feel safe at work and 86% experienced increased stress. Many workers also reported a lack of proper safety gear and training on how to avoid COVID-19 transmission, which contributed to stress and anxiety. Many retail workers also reported experiences with belligerent customers when trying to implement safety measures. In addition, the authors reported that low-wage essential workers were less likely than other workers to have access to safety gear, health insurance, or paid sick days, with more acute gaps among Black and Hispanic workers with low incomes.

Hirschmann, M. T., Hart, A., Henckel, J., Sadoghi, P., Seil, R., & Mouton, C. (2020). COVID-19 coronavirus: Recommended personal protective equipment for the orthopaedic and trauma surgeon. *Knee Surgery, Sports Traumatology, Arthroscopy*, 28(6), 1690–1698. <https://link.springer.com/article/10.1007/s00167-020-06022-4>

- Type of Research: Other (literature review)
- Summary: This study reviewed recommendations for PPE usage for worker protection in orthopedics and traumatology. The researchers reviewed existing literature on this topic and solicited expert recommendations. The research showed that trauma surgeons in the **United Kingdom** quickly adopted respirator and face protection measures suggested by UK Public Health England. Recommended PPE for orthopedic surgeons during the **COVID-19 pandemic** include a level 4 gown, face shield or goggles, double gloves, and N95 or other equivalent respirators. The authors conclude that surgical helmets and toga systems may not offer sufficient protection and that telemedicine can help contain and reduce the risk of COVID-19 exposure.

Nguyen, L. H., Drew, D. A., Graham, M. S., Joshi, A. D., Guo, C. G., Ma, W., Mehta, R. S., Warner, E. T., Sikavi, D. R., Lo, C. -H., Kwon, S., Song, M., Mucci, L. A., Stampfer, M. J., Willett, W. C., Eliassen, A. H., Hart, J. E., Chavarro, J. E., Rich-Edwards, J. W., ... Chan, A. (2020). Risk of COVID-19 among front-line health-care workers and the general community: A prospective cohort study. *The Lancet Public Health*, 5(9), e475–e483. [https://doi.org/10.1016/S2468-2667\(20\)30164-X](https://doi.org/10.1016/S2468-2667(20)30164-X)

- Type of Research: Causal (comparison group)
- Summary: The study examined the risk of **COVID-19** infection among health care workers, as

compared to the general public, to assess the level of risk protection granted by PPE in the workplace. The researchers gathered data using a **smartphone-based symptom tracking application** and **COVID-19 test results**. The results showed that health care workers were at an elevated risk for COVID-19 infection, even when adjusting for the possibility of increased access to testing. Post hoc analyses showed the adequacy of PPE, clinical setting, and background also contributed to the risk of becoming infected with COVID-19.

Scantling-Birch, Y., Newton, R., Naveed, H., Rajak, S., & Bhutta, M. F. (2021). See description in Section 3.

Warren, J. B., Norton, R., Nolt, D., Khan, F., & Guzman-Cottrill, J. A. (2020). Medical facemasks are adequate for healthcare worker safety at outdoor COVID-19 drive-through testing centers. *Infection Control and Hospital Epidemiology*. <https://doi.org/10.1017/ice.2020.1430>

- Type of Research: Descriptive (quantitative)
- Summary: This study examined the effectiveness of ASTM level 1 medical face masks on health care worker safety at drive-through **COVID-19** testing centers. To explore this, the authors used **COVID-19 test result data** for workers from three **Oregon** Health & Science University community testing sites, collected from March to October 2020. Based on these results, the authors conclude that ASTM level 1 face masks with eye protection, gowns, and gloves provide adequate protection for health care workers while collecting swabs for COVID-19 testing in an outdoor, drive-through setting.

6. Other citations supporting the synthesis

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Table 1. Examples of essential industries, businesses, services, and workers

Essential Industries and Business Types	Essential Businesses	Essential Services	Essential Workers
Health care operations and public health	Hospitals, medical practices, dentist offices, care facilities, home health workers, veterinarian and animal care, medical supply, biomedical, and laboratories	Treatment of COVID-19 patients, emergency services (e.g., treatment of cardiac episodes, surgery to address life-threatening conditions, care for accident patients), and obstetrics	Doctors, nurses, certified nursing assistants, dentists, and veterinarians
Human services operations	Social services, residential shelters and facilities, food banks, and nonprofit and religious organizations	Delivery of social service programs (e.g., the Supplemental Nutrition Assistance Program), operation of food banks	Social service case workers
Government operations and public safety	First responders, law enforcement, courts, corrections, and child welfare	Responding to emergency calls	Police officers, firefighters, dispatchers, other first responders, probation officers, judges, child welfare case workers
Infrastructure operations	Energy (e.g., electricity, nuclear, petroleum, natural and propane gas, coal, heating fuel); water/wastewater utilities; power facilities and transmission; trash services; communications and information technology; architecture and engineering services; construction and maintenance of dams and other essential infrastructure; airports, ports, roads, highways, and other transportation infrastructure; transportation and logistics services, including trade; public transportation; commercial lodging (e.g., hotels, motels); critical trades; chemical and hazardous materials; and military and defense industrial bases	Maintaining operation of electric services, trash collection, and disposal; maintaining information technology services, emergency road maintenance, and operation and maintenance of public transportation	Petroleum workers, natural and propane gas workers, trash collectors, road construction workers, air traffic controllers

Essential Industries and Business Types	Essential Businesses	Essential Services	Essential Workers
Manufacturing facilities	Facilities focusing on food processing, pharmaceutical development, medical equipment manufacturing, auto and transportation manufacturing, industrial manufacturing, and development of products used by essential businesses and related supply chains	Food preparation and packaging, manufacturing of essential goods	Food processing workers, warehouse workers, manufacturing workers
Agricultural operations and farms	Food, beverage, cannabis, and agricultural farms and businesses; businesses focused on forest products, fishing, aquaculture, and hunting	Food, beverage, cannabis, and agricultural production and transportation; food cultivation and processing; fishing and aquaculture; hunting; forest product preparation	Farmers, growers, packagers, truck drivers
Essential retailers	Food and beverage (e.g., restaurants and bars [most states noted for off-premises consumption only]; grocery stores, supercenters, and warehouse clubs; liquor stores; and marijuana dispensaries); pet and fishing supply stores; pharmacies and stores that sell medicine and medical supplies; retailers within health care, government, and transportation facilities; office supply and electronics stores; hardware, garden, and lawn stores; gun and ammunition shops; gas stations and convenience stores; auto and bicycle sales and rental; and businesses that ship food and goods to consumers	Sale of food, pet supplies, prescriptions, hygiene products, gas	Cashiers, stockers, gas station attendants

Essential Industries and Business Types	Essential Businesses	Essential Services	Essential Workers
Essential personal services	Mail and shipping services, financial institutions, home repair, auto and bicycle repair, laundromats, child care facilities, funeral services, custodial services, security services, lawn care, fumigation, couriers, roadside assistance, locksmiths, and other professional services (e.g., legal, accounting, insurance, real estate, administrative support)	Mailing packages, processing bank deposits, washing clothes, hosting funeral services, cutting grass	Postal workers, childcare workers, bank tellers, grass cutters
Other essential services and businesses	Media (including first amendment protected speech), educational institutions (including related child nutrition programs), critical labor union functions, outdoor recreation, and textiles	Delivering the news, teaching classes	Reporters, teachers

ABOUT THE RAPID REVIEW

This rapid review was created by Mathematica under the CLEAR contract with the U.S. Department of Labor (DOL), Chief Evaluation Office (CEO). The contents of the review do not represent the views or policies of DOL.

Due to the rapid turnaround for this review, the evidence scan did not follow CLEAR’s documented systematic approach. The evidence scan for this review had four components. First, CLEAR conducted a literature search using Google Scholar covering the dates since 2007. The search terms used for each strategy are provided in Table 2. Second, CLEAR reached out to experts in worker health- and safety-related fields to seek input on strategies and studies to include in the review. Third, citations from relevant studies were used to identify additional studies for review. Finally, CLEAR has conducted weekly searches to identify additional research released since the initial drafting. This version of the brief was last updated with literature published through August 2021. For additional details on how CLEAR conducts rapid reviews, see <https://clear.dol.gov/Reference-Documents/How-CLEAR-Conducts-Rapid-Evidence-Reviews>.

Table 2. Search terms

<p>("social distancing" OR "physical distancing" OR "physical barriers" OR "barrier controls" OR facemask OR "face mask*" OR "face covering*" OR "routine cleaning" OR disinfection OR "improving ventilation" OR "hand washing" OR "personal protective equipment" OR "PPE" OR screening OR testing OR "self-monitor*" OR isolat* OR quarantine* OR "social distanc*" OR sanitiz* OR "symptom* check*" OR "symptom* monitor*" OR "contact tracing" OR "deep cleaning" OR "ultraviolet" OR "fresh air" OR "engineering control" OR "ACH" OR "air changes per hour" OR "mask" OR "respirator" OR "disinfect*" OR "vaccin*" OR "immuniz*")</p>
<p>AND (Coronavirus OR COVID OR "SARS-CoV-2" OR pandemic OR "H1N1")</p>
<p>AND ("Work* health*" OR "work* safe*" OR "employee* health" OR "employee* safety" OR "work* protection*" OR (work* w/2 safety) OR ((business* OR employ* OR work*) w/3 "health and safety")</p>

CLEAR screened the abstracts of these studies to identify studies that examined specific interventions recommended by government and researchers and those implemented by businesses to protect workers during the COVID-19 pandemic.

Due to the rapid nature of this review, studies identified for review were not assessed

according to CLEAR’s causal evidence guidelines. Instead, reviewers used a short rubric to summarize information for each study. Each citation is classified by study type: causal, descriptive, or other. **Causal** research can assess the effectiveness of a strategy—in other words, whether there is a cause-and-effect relationship between the strategy and the results or impacts. High-quality causal research (impact studies) can produce the most credible type of evidence. **Descriptive** research does not determine cause-and-effect relationships but uses quantitative methods to identify trends, correlations, projections, and costs and benefits of actions taken. CLEAR also categorized qualitative studies under the descriptive category for the purposes of this rapid review. CLEAR’s rapid reviews also summarize **other** types of evidence and research that describe how, where, and why strategies are implemented and include opinion pieces by subject matter experts. This type of research does not aim to identify cause-and-effect relationships or use quantitative or qualitative methods but can be useful to identify emerging strategies potentially worthy of future replication and additional study. For more information on how CLEAR reviews and rates different types of studies, see CLEAR’s reference documents at <https://clear.dol.gov/about>.

Mathematica prepared this rapid review for the Chief Evaluation Office of the U.S. Department of Labor under Contract #DOLQ129633249/DOL-OPS-16-U-00086. The views expressed are those of the authors and should not be attributed to the Federal Government or the Department of Labor.