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Responding to the COVID-19 Pandemic in the Construction Industry

Jessica Bunting
Amber Trueblood
Richard Rinehart
Chris Trahan Cain

CPWR - The Center for Construction Research and Training

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8484 Georgia Avenue
Suite 1000
Silver Spring, MD 20910

PHONE: 301.578.8500
FAX: 301.578.8572

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Abstract

COVID-19 had a significant impact on the construction industry, whose workers were labeled “essential” and therefore largely remained on the job. This paper describes how CPWR helped control the spread of COVID-19 in the construction industry by: 1) developing and disseminating educational materials and providing guidance on best practices for stopping the spread of viruses, 2) tracking and analyzing data on COVID-19 and COVID-19 vaccination, and 3) evaluating the effectiveness of distance learning methods and sharing the findings broadly to assist others in continuing important safety and health training programs. The lessons from these efforts provide a framework for an expedited response to future public health crises that can be applied to construction and other industries with essential workers in similar working conditions.

Table of Contents

Introduction

In early 2020, it became apparent the Sars-CoV-2 virus, commonly called COVID-19 and coronavirus, was going to have significant impact on the United States, including the construction industry. However, there was a lack of knowledge, particularly construction-specific, science-based guidance, around preventing COVID-19 spread. The Federal government provided guidance on the protection of critical infrastructure during the pandemic and included construction workers as essential workers in March 2020. However, states and municipalities ultimately set their own policies and orders. [1] The resulting local requirements relevant to construction varied widely throughout the country, with numerous and sometimes inconsistent guidelines and mandates accompanying them.

Construction workers were often deemed essential throughout even the worst outbreaks, potentially putting them at higher-than-average risk of contracting the virus. In addition, an article published early in the pandemic predicted that continued construction work would increase virus spread to the broader community, further spotlighting the need for worker protection. [2] Construction site conditions and the decentralized nature of the industry complicated matters, often making the implementation of COVID-19 control measures challenging. For example, job sites frequently lack running water or hand-washing facilities and have enclosed spaces without ventilation and with multiple crew members working closely together. Tools and equipment are also regularly shared. Crews and individual workers move from job site to job site, increasing opportunities for exposure and transmission. There were many concerns and questions on how to keep workers safe from the virus if construction work was to continue throughout the pandemic.

This paper describes actions taken by CPWR—The Center for Construction Research and Training (CPWR), in close partnership with the Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH), to help control the spread of COVID-19 in the construction industry. It discusses steps taken to translate CDC and other guidance, along with recommendations from employers, building trades unions, and government agencies, into actionable resources tailored for the construction industry. At the request of North America's Building Trades Unions (NABTU), an umbrella labor organization of 14 building trades unions that together represent over three million construction workers, this information was compiled in April 2020 into a workplace standard to keep workers safe, including information on what workers should expect and measures employers need to implement on job sites. [3] This article also explains actions taken by CPWR's Research to Practice (r2p) and Communications programs to reach employers, safety and health professionals, workers, and other industry members through webinars and podcasts and to provide free resources, educational materials, and online tools. It then describes data reports and data dashboards developed by the CPWR Data Center to track and analyze pandemic-related surveillance data such as employment trends, construction worker mental health, and vaccination rates. Finally, the risks of in-person training led to rapid changes to the delivery of safety and health training by the CPWR Training Department. Those changes, as well as an evaluation of new distance-learning methods, are briefly summarized.

CPWR is a non-profit organization established by NABTU more than 30 years ago and continues today with a mission to reduce occupational injuries, illnesses, and fatalities in the construction industry. It also operates the National Construction Center for the National Institute for Occupational Safety and Health (NIOSH). [4] Because of its foundational relationships with trade unions and other construction stakeholders, CPWR, together with NIOSH, was well-positioned to bring together people from across the industry—including researchers, safety and health professionals, and members of the medical community—to help lead the way in sharing up-to-date information and developing practical resources and recommendations to protect construction workers from COVID-19.

Lessons learned while coordinating a proactive and responsive effort to protect workers throughout the pandemic can be applied to future instances of disease or disaster when causes are not known and our collective understanding of risks and protective measures is rapidly changing.

Coordinated Response

This article describes CPWR's coordinated response to the pandemic, including how our research and training programs worked together with NIOSH and critical partners such as NABTU and the Occupational Safety and Health Administration (OSHA) to develop, identify, and disseminate guidance and best practices for reducing COVID-19 exposure in the construction industry, all while keeping our recommendations at least as protective as the evolving NIOSH, CDC, and OSHA guidance in order to keep workers and their families safe and ensure essential construction projects could continue throughout the pandemic.

2.1. COVID-19 Standard for U.S. Construction Sites

On April 27, 2020, the NABTU and CPWR COVID-19 Standards for U.S. Construction Sites was published as one of our first actions taken to respond to the pandemic. [3] It translated myriad recommendations being produced at the time into a single practical guide for the construction industry by specifying the minimum actions employers should take as part of written COVID-19 exposure control plans on all job sites. It outlined in straightforward terms how employers could develop site-specific, comprehensive COVID-19 plans for exposure control, symptom checking, social distancing, hygiene and decontamination procedures, training, and more. The development of these standards was critical at a time when regulators were hesitant to make decisions and the industry was lacking informed or consistent guidance on carrying out recommendations from the CDC and other medical professionals.

2.2. Moving Research into Practice: Communication, Outreach, and Education

CPWR's Research to Practice (r2p) and Communications programs, which work closely together to accelerate wide-spread adoption of research findings and evidence-based solutions by employers and their employees to prevent occupational injuries and illnesses, coordinated many of the organization's efforts with NIOSH and others. Together they generated numerous resources to raise awareness of COVID-19, helped employers develop written exposure control plans, and increased use of protective measures such as better hygiene, appropriate use of personal protective equipment (PPE), and vaccination.

On April 22, 2020, CPWR and The Association of Union Constructors (TAUC) co-hosted a webinar on COVID-19 and the Construction Industry. [5] This webinar included NIOSH Director Dr. John Howard and other representatives from NIOSH, CPWR, and TAUC. Its aim was to educate industry members on the basics of COVID-19 – what it is, how it was thought to spread, how to protect workers, etc. The webinar was attended live by 1,136 people and viewed another 2,512 times on-demand after being posted on YouTube.

Based on the popularity of that initial webinar and the number of questions from attendees, CPWR and NIOSH started a regular COVID-19 Webinar Series. We found there was an ongoing need for this type of regular virtual education, information sharing, and updates from our industry and ultimately produced 22 webinars from April 2020 to January 2022 that directly responded to requests and questions from our target audiences. [5] Together they have had more than 9,000 live attendees and approximately 10,000 on-demand views. Topics included medical information about the virus, lessons from the job site, new tools and resources, managing mental health, effective delivery of training during the pandemic, and regular updates on guidance from NIOSH, CDC, OSHA, and others, including experts from the Georgetown University School of Medicine, Colorado School of Public Health, National Institute for Environmental Health Sciences (NIEHS), Oregon State Building and Construction Trades Council, Sheet Metal Occupational Health Institute Trust, and various construction companies. Table 1 lists the webinar topics.

Table 1. COVID-19 Webinar Series by Date, Number of Live Participants, and Number of On-Demand Views.

Webinar	Date (M/D/Y)	Live Participants	On-Demand Views[1]
COVID-19 and the Construction Industry	4/22/2020	1,136	2,567
COVID-19 - Data-Driven Insights on Job Site Activity	6/3/2020	496	477
COVID-19 - Updates on Centers for Disease Control and Prevention (CDC) Guidance	6/17/2020	970	990
COVID-19 - Safety in Action: An Example from the Job Site	7/2/2020	559	589
COVID-19 Contact Tracing - How it's done, and how you can help	7/16/2020	665	487
Addressing COVID-19's Health Disparities	7/30/2020	390	267
COVID-19 - Lessons from the Job Site: A Q&A Panel	8/13/2020	314	269
Mental Health During the COVID-19 Pandemic	8/27/2020	323	335
COVID-19 - What We've Learned: Health Risks and Prevention	9/10/2020	202	228
Responding to COVID-19 on the Job Site: News from the Oregon COVID-19 Joint Construction Safety Task Force	9/24/2020	202	220
Impact of COVID-19 on the Industry and New Research Initiatives	10/8/2020	190	149
Construction Leadership Skills for Managing Stress During the COVID-19 Pandemic	10/22/2020	218	445
National Institute of Environmental Health Sciences (NIEHS) Activities, Tools and Resources to Protect Workers from COVID-19	11/12/2020	293	285
Effectively Delivering Safety and Health Training During the COVID-19 Pandemic	12/3/2020	388	221
National Institute for Occupational Safety & Health (NIOSH) Activities Supporting the Optimization of Respiratory Protection	12/17/2020	252	327
Vaccination & Ventilation: A Conversation about Next Steps in COVID-19 Prevention	1/28/2021	602	363
Protecting Construction Workers: Guidance on Mitigating and Preventing the Spread of COVID-19 in the Workplace	2/25/2021	464	539
An Update on COVID-19 Vaccinations and Questions & Answers with CDC's Essential Workers Team	3/18/2021	296	194
Occupational Safety and Health Administration's (OSHA) National Emphasis Program for COVID-19	4/13/2021	262	320
COVID-19 Science and Policy Update with Dr. John Howard	5/13/2021	329	210
Update on OSHA Guidance for Workers Not Covered by the COVID-19 ETS	7/9/2021	275	532
COVID-19 Back to Basics	1/13/2022	205	173

[1] On-demand views through July 2023.

Concrete, consistent, and generalizable recommendations for construction employers to prevent the spread of COVID-19 on their job sites were difficult to find at the beginning of the pandemic. Employers wanted to protect themselves and their employees. Unions wanted to protect their members. But guidance from medical and public health professionals was often unclear or not specific enough to be applied in practice on job sites. At the request of industry and labor partners, CPWR created an online repository of information that helped construction employers and others find the latest research results, clear guidance, and solutions being used by peers all in one place. The COVID-19 Construction Clearinghouse website was launched in May 2020. [6] It was designed to be a first stop for anyone looking to reduce virus exposure in construction or similar settings. Over the next year and a half, CPWR added hundreds of resources to the Clearinghouse gathered through various networks including NIOSH, the National Occupational Research Agenda's (NORA) Construction Sector Council's COVID-19 Work Group, OSHA, university researchers, state and local governments, and construction employers. Resources were either identified by CPWR staff or submitted through a portal on the website. All materials were vetted prior to being posted, and every effort was made to keep up with scientific research and advances in good practices as the nation collectively learned more about the virus and how to protect against it. Because the situation was developing at a rapid enough pace that expert guidance was not always immediately available, the ability to share best practices from others in the field was crucial to protecting workers. Once the vaccine became available, there was even more rapidly changing and conflicting information available, so having a collection of vetted information that contractors and workers could trust was of the utmost importance.

Shortly after the Clearinghouse was launched, CPWR developed a complimentary interactive tool that helped employers develop written, site-specific exposure control plans to protect workers and visitors. In September 2020, the COVID-19 Exposure Control Planning Tool went online. [7] The website walked users through the creation of a plan by asking them to answer a series of questions and linking directly to articles, guidelines, and other resources in the Clearinghouse for more information on how to implement specific controls. Construction employers often use written exposure control plans to minimize the risk of exposure to jobsite hazards such as silica or noise, making this planning process familiar even though the exposure itself was new.

CPWR's r2p Program also worked closely with NIOSH and diverse partners to develop COVID-19-specific educational products, such as Toolbox Talks, infographics, and a regularly updated set of frequently asked questions (FAQs) on the topic of vaccination. One of the first products developed was a Toolbox Talk, in both English and Spanish, for use by contractors and supervisory workers at jobsite meetings. Toolbox Talks are our most downloaded resource on cpwr.com, and users frequently enter our website after searching some variation of the term "toolbox talk" on Google, so we already knew that they are a popular way for management to educate workers on jobsite hazards and protective measures. The COVID-19 Toolbox Talk, published in April 2020, included information about the virus and protective measures in a format that encourages discussion among the work crew. [8] Additional materials included a series of COVID-19 infographics that incorporated new information and the introduction of the vaccine. The goal of these infographics was to communicate small, digestible pieces of information in a clear and simple way, again in both English and Spanish. Three early infographics focused on maintaining six feet of distance, good hygiene practices, and proper mask or respirator use. [9]

Later, a set of four COVID-19 Vaccine Fact Infographics were added, followed by a set of five more in addressing vaccine effectiveness, vaccine side effects, the science of breakthrough infections, population immunity, and who should get the vaccine. [10] CPWR worked with NIOSH and several partners to develop the vaccine infographics, including the University of Michigan School of Public Health Department of Environmental Health Sciences, The University of Texas Health Science Center at Tyler, and the Washington University School of Medicine in St. Louis Healthy Work Center. Working with these partners, CPWR also put out several additional COVID-19 vaccine resources that provided more detailed information for those interested, including: COVID-19 Vaccine FAQs for the Construction Industry (available in English and Spanish), Why Is It Important for Construction Workers to Get Vaccinated?, and Promoting Vaccination Among Small Construction Firms. [10] The COVID-19 Vaccine FAQs was updated

seven times to reflect the current science and CDC/NIOSH recommendations. The vaccine-related infographics included links to the more detailed FAQs and/or the COVID-19 Construction Clearinghouse but were kept simple to be used on social media and as job site posters while also providing users with the opportunity to go more in-depth – either individually or as crew training.
The guidance document Quick Tips to Increase Ventilation at Indoor Construction Sites Without Operating HVAC Systems was published in English and Spanish to directly respond to contractors' concerns around work that must be done indoors without functional heating, ventilating, and air conditioning systems or in other settings with limited air flow and filtration. [11] The recommendations were influenced in part by the findings of a short survey, administered by CPWR, described in the report, Ventilation to Reduce COVID-19 Spread in Enclosed Work Areas During Cold Weather: A Survey of Construction Contractors. [12] All of these resources were included for free on the COVID-19 Construction Clearinghouse and added to the main CPWR website. [6, 13] They were also heavily promoted through the CPWR-NIOSH webinar series, CPWR's podcasts, social media, articles in trade publications, traditional media outlets, numerous presentations, CPWR's monthly newsletter (sent to more than 15,000 subscribers), and through external partners for a broader reach.

2.3. Tracking the Impact of COVID-19

CPWR's Data Center provides timely and reliable statistics] on construction safety and health and other industry trends. In response to the pandemic, the Data Center conducted many analyses to understand the immediate, intermediate, and longer-term impact of COVID-19 on the construction industry. The key findings from these analyses were presented through two of its main products, Data Bulletins and interactive Data Dashboards.

Data Bulletins, produced six times per year, provide concise details on selected topics with charts and descriptive narratives. From May 2020 to September 2022, multiple Data Bulletins examined the impact of the pandemic on the construction industry.

The first CPWR COVID-19 Data Bulletin, titled Coronavirus and Health Disparities in Construction, was published in May 2020 using data from the U.S. Census Bureau's Current Population Survey and the National Center for Health Statistics National Health Interview Survey. [14] It provided timely statistics on employment and health of construction workers early in the pandemic to assess the potential risk of severe illness from COVID-19 among construction workers.

From June 2020 to July 2022, there were an additional seven COVID-19 Data Bulletins published on the impact of the pandemic on the workforce, employment trends, business characteristics, vaccination rates, OSHA inspections, and mental health. Table 2 provides a timeline, as well as an overview of the topics covered. [15] The most downloaded Data Bulletin was OSHA Inspections and Citations for Fall Protection in Construction and the Impact of COVID-19. [16] The most recent focused on the Impact of COVID-19 on the Construction Industry: 2 Years in Review, published in July 2022. [17] It provides a comprehensive examination of the pandemic over the past two years and summarizes changes in spending, employment, and the impact on contractors; OSHA inspections and citations; and worker safety and health in construction. Three additional Data Bulletins not included in Table 2 contained information about the pandemic: Employment Trends and Projections in Construction; Fatal and Nonfatal Injuries in the Construction Industry; and Fatal and Nonfatal Transportation Injuries in the Construction Industry, 2011-2020. [18-20]

Table 2. CPWR COVID-19 Pandemic Data Bulletins by Publication Date, Topic, and Number of Downloads

Data Bulletin	Publication Date	Topic	Downloads[1]
Coronavirus and Health Disparities in Construction	May 2020	Health Disparities	335
Impact of COVID-19 on Construction Workers and Businesses	July 2020	Workers, Businesses	292
Impact of COVID-19 on Construction Businesses and Productions	November 2020	Businesses	258
Construction Employment, Businesses, and COVID-19 Vaccinations During the Pandemic	June 2021	Vaccinations	356
Occupational Safety and Health Administration's (OSHA) Inspections and Citations for Fall Protection in Construction and the Impact of COVID-19	September 2021	Enforcement	419
Construction Safety Management During the COVID-19 Pandemic	November 2021	Safety Management	281
Construction Worker Mental Health During the COVID-19 Pandemic	January 2022	Mental Health	356
Impact of COVID-19 on the Construction Industry: 2 Years in Review	July 2022	Economy, Businesses, Injuries, Illnesses, Vaccinations	228

[1] Unique downloads through August 2023.

In addition to Data Bulletins, CPWR's Data Center produces Data Dashboards that provide interactive charts on specific topics. Three of the dashboards published since May 2021 focused on the pandemic. The first, COVID-19 Vaccination dashboard, was originally published to accompany the June 2021 Data Bulletin, Construction Employment, Businesses, and COVID-19 Vaccinations During the Pandemic. [21, 22] It provides four charts on vaccinations within the construction industry, including vaccination rate by state, occupation, hesitancy, and barrier information. This dashboard was updated monthly until June 2022, when the Delphi Group at Carnegie Mellon, the primary data source, stopped conducting the COVID-19 Trends and Impact Survey. The second dashboard, Construction Worker Mental Health, was published to accompany the January 2022 Data Bulletin, Construction Worker Mental Health During the COVID-19 Pandemic. [23,24] Construction Employment Trends, the final dashboard, was published to accompany the March 2022 Data Bulletin, Employment Trends and Projections in Construction. [25,18] This dashboard includes a series of charts examining construction employment and COVID-19, including employment by subsector, demographics, as well as employment changes.

Finally, the Construction Safety Management Survey, conducted periodically by Dodge Data & Analytics (DD&A) in partnership with CPWR, integrated questions on safety measures adopted during the COVID-19 pandemic. [26] Questions covered how influential the pandemic was on increasing online training, impact of COVID-19 on employment, if the company developed a written plan to protect job site workers to prevent the spread, and health and safety measures instituted due to the pandemic and which they plan

to keep after the pandemic. Findings from this survey were included in the DD&A SmartMarket Report: Safety Management in the Construction Industry 2021 and in CPWR's November 2021 Data Bulletin, Construction Safety Management During the COVID-19 Pandemic. [26, 27] CPWR's Data Bulletin builds on DD&A's report by detailing trends by construction firm types, union status, and firm size.

2.4. Training During the Pandemic

The COVID-19 pandemic forced CPWR's Training Program, which is funded by the National Institute for Environmental Health Sciences (NIEHS) and partners with NABTU unions to support construction worker training on a national level, to stop in-person training and quickly transition to synchronous distance learning and online communication. This was a major challenge, as health and safety and skill-based training in construction typically relies on in-person interaction and hands-on training. The abrupt shift to distance learning formats caused several issues for CPWR and others that provide worker safety and health training, such as unfamiliar platforms, absence of online resources, compliance and ethical considerations, and a lack of resources to assess the effectiveness of the new format. These difficulties highlighted the need for systematic evaluations to monitor the effectiveness of distance learning methods and make necessary improvements.

The pandemic also emphasized the importance of sharing lessons learned and best practices as training systems evolved to meet worker safety and health needs. CPWR designed and implemented a research project to assess the effectiveness and sustainability of distance learning in occupational health and safety training. [28] The resulting report provides preliminary evidence supporting the effectiveness of the distance learning format in delivering training, identifies factors that affect effectiveness and impact, offers recommendations for continuous quality improvement, and provides suggestions for future research on the use of distance learning technology. These findings and recommendations informed the creation of Best Practices for Distance Learning, three one-page handouts produced by the CPWR r2p program to help instructors and students maximize the benefits of online training. [29] These handouts cover topics such as excellence in distance learning, using breakout rooms, and online etiquette. Overall, this work, which was presented during one session in the CPWR/NIOSH COVID-19 webinar series, provides a foundation for successful and sustained integration of synchronous distance-learning occupational health and safety training in the future.

Discussion

CPWR's COVID-19 resources were well received and wide reaching. The COVID-19 webpages on the main CPWR website were viewed 57,000 times, including nearly 45,000 unique views, between initial publication and the end of July 2023. The COVID-19 webinar series had more than 9,000 live participants and about 10,000on-demand views. In general, the earliest webinars in the series were the best attended; there were also themes that rose to the top in popularity. Audiences were particularly interested in updates on NIOSH, CDC and OSHA guidance and how it should be applied in the construction workplace. Mental health and managing stress were also of significant interest, reflecting the increasing willingness of the broader public to discuss difficult or "taboo" topics such as depression, anxiety, suicide, and substance use disorders. [30]

CPWR's Data Center Data Bulletins and Dashboards related to the pandemic were well received, with 2,525 2,531 downloads and 8,584 8,694unique views, respectively. The most viewed or downloaded Data Bulletins and Dashboards covered vaccinations, mental health, and OSHA inspections and citations.

From the launch of the COVID-19 Construction Clearinghouse in May 2020 through August 2022, the site has had over 43,000 page views. The most viewed resource sections were, in order, Vaccines, Guidance on Workplace Practices, Training Resources, Employer Recommendations and Requirements, and Safety in Action (provide real-life examples from construction jobsites). Since the COVID-19 Exposure Control Planning Tool went online in September 2020, over 8,400 users have generated over 20,000 pageviews. Of

those who visited the site, nearly a quarter (n=2,039; 24.3%) continued to the section to create a written COVID-19 work plan.

CPWR's actions and resources to help the construction industry protect workers from COVID-19 were picked up by government, safety and health, union, and construction trades news sources from March 2020 through the first half of 2023. These ranged from NIOSH eNews, Safety+Health Magazine, EHS Today, Engineering News-Record, Construction Dive, and others.

Several lessons from the COVID-19 pandemic and our response to it can be applied to future disaster and disease response efforts, as well as to our ongoing research to practice, training, and other work. Some of the resources that we created can easily be updated in the event of another pandemic, enabling a faster response than at the start of COVID-19. But perhaps more importantly, as an organization we have learned how to quickly shift gears to respond to an emerging priority hazard. As the NIOSH National Construction Center and an NIEHS-funded training center, CPWR's programmatic aims and the steps to achieve them are laid out for years in advance. Our staff was required to change these plans to respond immediately and directly to the pandemic and the needs of the industry.

Lessons Learned

Another lesson learned was the need for partnerships and the importance of both existing and new networks to identify subject matter experts, best practices, and accurate resources when the science takes time to develop but speed is crucial to saving lives. Interpreting guidance from the CDC, OSHA, and others is challenging in normal circumstances, and doing so when there are many uncertainties about the risks and preventive measures could not have been accomplished without invested partners from academics to medical professionals to industry representatives.

Reliable, rapidly collected surveillance data were found to be key in obtaining baseline information on construction workers, as well as tracking immediate, intermediate, and long-term impacts of both the virus and the preventive measures being taken. For example, U.S. Bureau of Labor Statistics Current Population Survey and data from the National Health Interview Survey, which were published within two months of the pandemic, were used to identify workers at a higher risk for COVID-19. [14] The July 2022 CPWR Data Bulletin combined multiple data sources to examine the impact of the pandemic on the construction industry over a 2-year period, highlighting both short and long-term impacts. [17] Various user statistics highlight the types of information and resources our audiences are most interested in and that can guide the development of future materials and r2p efforts. Website analytics, webinar attendance, and other statistics showed that industry members were interested in guidance being translated to easy-to-digest formats specific to the construction industry. Mental health and stress management emerged as topics of interest due to the impact of the pandemic on our lives. [31]

Training efforts during the pandemic provided evidence supporting distance learning as an effective means for delivering occupational health and safety training. Specifically, through our experience thus far in delivering construction safety and health training via the Zoom platform, these are additional lessons learned that could broadly apply to all worker training programs.

> **Data Collection** - One challenge that was quickly identified was the need to collect trainee data when conducting the live distance learning training courses utilizing Zoom. CPWR's research staff quickly proposed repurposing a survey collection software to capture all required student data and allow staff to easily insert it into our student database.

Staffing On-line Courses – Each live online course was staffed with a minimum of two instructors, regardless of course duration. There were several instances in which the presenter experienced connection issues. Having a second, trained instructor available prevented disruption to the training.

Duration of On-line Training – Trying to sit through a full day of online-based instruction posed a challenge to effective and impactful training. We found that 3 to 4 hours at a time is the maximum for conducting synchronous training. For example, this rule re-shaped the format of the 6-hour CPWR Infection Control Risk Assessment (ICRA)/COVID-19 Awareness Training so that the virtual training is held over two days using 3-hour blocks on each day.

Limiting Use of Smartphones – CPWR encourages students to access its live online courses through a computer or tablet rather than a smartphone. The small screens of most smartphones pose a challenge to the student's ability to read slides and can also reduce their ability to fully participate in small-group breakout sessions that sometimes require writing on a shared virtual "whiteboard."

Conclusions

The construction industry was particularly vulnerable to COVID-19 because its essential workforce largely worked throughout the pandemic. CPWR, with NIOSH, quickly responded to address the needs of the industry throughout the development of guidance documents, webinars, infographics, factsheets, Data Bulletins, and Data Dashboards, all of which were well received. Through the response, key lessons were identified that can be applied to the needs of the construction industry.

Recommendations for Future Research

Data Center research revealed significant health disparities among construction workers in comparison to other industries. Construction workers are more likely to be Hispanic, more likely to smoke cigarettes, and more likely to have at least one factor putting them at a higher risk of severe illness from COVID-19 (age 65+, medical condition, etc.). [14] More research could be done on how to mediate these factors, for example through paid sick leave and better health insurance.

Through our response it was found the construction industry was less likely to adopt and implement public health measures. For example, the COVID-19 Vaccination Dashboard found in June 2022 82.5% of all workers were vaccinated, but only 54.3% of construction workers were. [21] Alsharef et al. (2021) reported challenges with construction workers wearing face coverings and social distancing. [32] Barriers to construction workers adopting public health measures should be further researched.

Additional research is also needed on how to best disseminate information in response to an emergency (i.e., in a timely manner). We know that we were effective in our research to practice efforts to a degree, based on our reach and an increase in newsletter and webinar registrations during this period; however there are still many audiences that are difficult for us to reach, such as small contractors and non-union workers. There is a need for more research on how to disseminate to these audiences in general, but it would be useful to study how to do so in the unique circumstances of a pandemic or other large-scale emergency response.

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