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Virginia CTE Career Cluster and Pathway Employment Vulnerability to COVID-19

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EXECUTIVE SUMMARY

The COVID-19 virus was first detected in the Wuhan province of China but rapidly spread to Europe, North America, and elsewhere through business and tourist travel. The outbreak caused an unprecedented national public health crisis that quickly spilled over into the economy, causing the most rapid economic downturn since the Great Depression. Although federal fiscal and monetary policies, public health measures, household behavioral changes, and relatively rapid development and administration of vaccines helped to mitigate the downturn, the economic recovery has been uneven across industries, occupations, regions, and demographic and socioeconomic groups. Service and retail trade industries providing nonessential goods and services—such as food service, hospitality, and accommodation—and occupations where teleworking is difficult have been affected the most. Regions particularly reliant on those industries and occupations, such as tourist destinations and city centers, have been particularly hard-hit. Industry and occupational impacts have also been unevenly distributed across workers: lower-wage earners, racial and ethnic minorities, and women have experienced more displacement than other groups.

Although the worst of the COVID-19 economic crisis has passed, many analysts predict that the economic and social forces unleashed by the pandemic will continue to exert long-term structural effects on the economy and workforce far into the future. Among the long-term effects will be a greater propensity for workers to work remotely (i.e., telecommute) for safety, productivity, and lifestyle reasons. Workplace automation will accelerate because of experimentation that occurred during the pandemic, business uncertainties, and a pattern of continued technology substitution observed during recessions. Workers who elect to live remotely and telecommute will generate lower demand for city-center services and amenities, which may have additional detrimental effects on the leisure and hospitality and retail trade industries concentrated there.

This paper examines the effect of COVID-19 on the national and Virginia economies, with particular attention to asymmetrical supply-side shocks on occupations and career choices. It examines occupational risks associated with the pandemic along four dimensions: (a) workplace disease exposure, (b) ability to work at home, (c) exposure to automation due to the routine nature of workplace tasks, and (d) designation as a critical workforce occupation. The paper measures these occupational dimensions with the aid of research published during the pandemic, including studies that used Occupational Information Network (O*NET) data on work context and work activities to characterize occupational pandemic vulnerability, and a list of critical occupations compiled by the LMI Institute and Council for Community and Economic Research (C2ER) based on Department of Homeland Security documents. These occupational risk measures are mapped onto Career and Technical Education (CTE) career clusters and pathways to determine which ones have been most affected by the pandemic and are more likely to experience growth and decline in the future as a result of long-term structural changes. During the pandemic (i.e., in the "short run"), all four occupational dimension risks have shaped the employment environment. After the pandemic (i.e., in the "long run"), disease exposure and essential industry designation will no longer be paramount in shaping employment patterns; however, teleworking potential and automation will continue to be important.

Results indicate that career clusters vary widely in terms of their anticipated short-term and long-term pandemic vulnerabilities. The *Marketing* cluster is exposed in both the short run and in the long run. Occupations in the *Marketing* cluster are more likely to involve disease exposure, have limited remote work potential, be vulnerable to automation, and be designated as noncritical. Such occupations generally require a significant amount of face-to-face contact with coworkers and customers. Two other career clusters (*Law, Public Safety, Corrections, and Security* and *Human Services*) have also been under short-term pressure during the pandemic because of greater disease exposure, lower capacity for remote work, and lower likelihood to consist of occupations designated as essential. Long-term vulnerability of these two clusters, however, is lower. The four career clusters at long-term risk mainly because of lower remote work potential and greater automation risk are *Agriculture, Food and Natural Resources; Architecture and Construction; Hospitality and Tourism;* and *Manufacturing*.

An analysis of wage, educational, and nontraditional gender employment data reveals several other patterns. First, high-vulnerability occupations tend to be lower-paid and were projected to grow more slowly even before the pandemic. Disparities by gender and education level also exist. Among less vulnerable vocations, females tend to be underrepresented, and a bachelor's degree is the predominant educational level. In contrast, among high-vulnerability occupations, females tend to be overrepresented, and some college or an associate degree is the predominant educational level. These findings corroborate disparities in COVID-19 economic and demographic impact described in other national studies. The findings also point to the importance of postsecondary degrees and promotion of nontraditional career paths for women to ensure lower short-term and long-term pandemic career risks and greater labor market success.

Since the most effective job preparation aligns with employer needs and adapts to changes in the economy and labor markets, CTE programs should make allowances for changes that will result from the pandemic. These changes should be addressed in Comprehensive Local Needs Assessments required as part of the Strengthening Career and Technical Education for the 21st Century Act (Perkins V). Labor market assessments developed before the pandemic may need to be reevaluated for currency and relevancy in the post-pandemic environment to ensure that program and course offerings align with business and industry labor market needs. Virginia CTE administrators have traditionally relied on occupational projections released by the Bureau of Labor Statistics (BLS) and Virginia Employment Commission (VEC) in determining occupations, career clusters, and pathways with the greatest growth potential. Unfortunately, regional labor market data reflecting pandemic effects within Virginia’s Local Workforce Development Areas (LWDAs) are not likely to be available until summer 2023, based on previous data release timing. The temporary absence of occupational projections that reflect COVID-19 impacts may mean local decision makers need to place more weight on employer feedback, employer surveys, real-time labor market analytics, and other information, such as the analysis of COVID effects described in this report, until a clearer picture emerges from occupational projections more reflective of COVID-19-induced changes when they are released in the next two years.

Changes in skills, technology, and labor markets will also need to be addressed at the curricular and career counseling levels. In response to potential occupational vulnerabilities to future automation, CTE administrators and teachers may want to consider expanding curricular exposure to new and emerging technologies in introductory courses. Additionally, it will be imperative that students are kept up-to-date on the latest automation trends within specific occupations to be certain they are being taught skills that will prepare them to work with and alongside the latest technologies in their chosen fields. Training in these more specific skill sets might best be incorporated into higher-level CTE courses or Work-Based Learning experiences that are focused on preparing students for specific career fields or occupations. And last, but certainly not least, workplace readiness skills that help students prepare to adapt to changing workplace conditions in the future—such as critical thinking, problem-solving, continuous learning, and adaptability—should continue to be emphasized and integrated into CTE course curricula.

IMPACT OF COVID-19

1. Introduction

The rapid spread of the deadly COVID-19 virus caused an unprecedented national public health crisis that set in motion sweeping containment efforts. A wide range of mitigation strategies were used, including social distancing in public places, mandated personal protective equipment (PPE) usage, stay-at-home orders, and temporary closures of nonessential businesses.

The health crisis quickly spilled over into the economy, causing the largest plunge in national economic output and employment since the Great Depression (Siegel and Van Dam 2020). Federal fiscal and monetary policies, public health measures, household behavioral changes, and relatively rapid development and administration of vaccines helped to shorten and dampen the downturn. However, the economic impacts of the recovery have been uneven across industries, occupations, regions, and demographic and socioeconomic groups in what many economists have characterized as a "K-shaped" recovery. Service and retail trade industries providing nonessential goods and services—such as food service, hospitality, and accommodation—and occupations where teleworking is difficult have been affected the most. Regions particularly reliant on those industries and occupations, such as tourist destinations and city centers, have been particularly hard-hit. Industry and occupational impacts have also been unevenly distributed across workers: lower-wage earners, racial and ethnic minorities, and women have experienced more displacement than other groups.

Many economic analysts predict that the economic and social forces unleashed by the pandemic will continue to exert long-term structural effects on the economy and workforce years after the pandemic recedes. Among the long-term effects will be a greater propensity for workers to work remotely (i.e., telecommute) for safety, productivity, and lifestyle reasons. Workplace automation will accelerate because of experimentation that occurred during the pandemic, business uncertainties, and a pattern of continued technology substitution observed during recessions. Workers who elect to live remotely and telecommute will generate lower demand for city-center services and amenities, which may have additional detrimental effects on the leisure and hospitality and retail trade industries concentrated there.

This paper examines the effect of COVID-19 on the national and Virginia economies, with particular attention to asymmetrical supply-side shocks on occupations and career choices. It examines occupational risks associated with the pandemic along four dimensions: (a) workplace disease exposure, (b) ability to work at home, (c) exposure to automation due to the routine nature of workplace tasks, and (d) designation as a critical workforce occupation. The paper measures these occupational dimensions with the aid of research published during the pandemic, including studies that used Occupational Information Network (O*NET) data on work context and work activities to characterize occupational pandemic vulnerability, and a list of critical occupations compiled by the LMI Institute and Council for Community and Economic Research (C2ER) based on Department of Homeland Security documents. These occupational risk measures are mapped onto Career and Technical Education (CTE) career clusters and pathways to determine which ones have been most affected by the pandemic and are more likely to experience growth and decline in the future as a result of long-term structural changes. These findings can help inform occupational counseling and CTE program planning during a period of change and uncertainty.

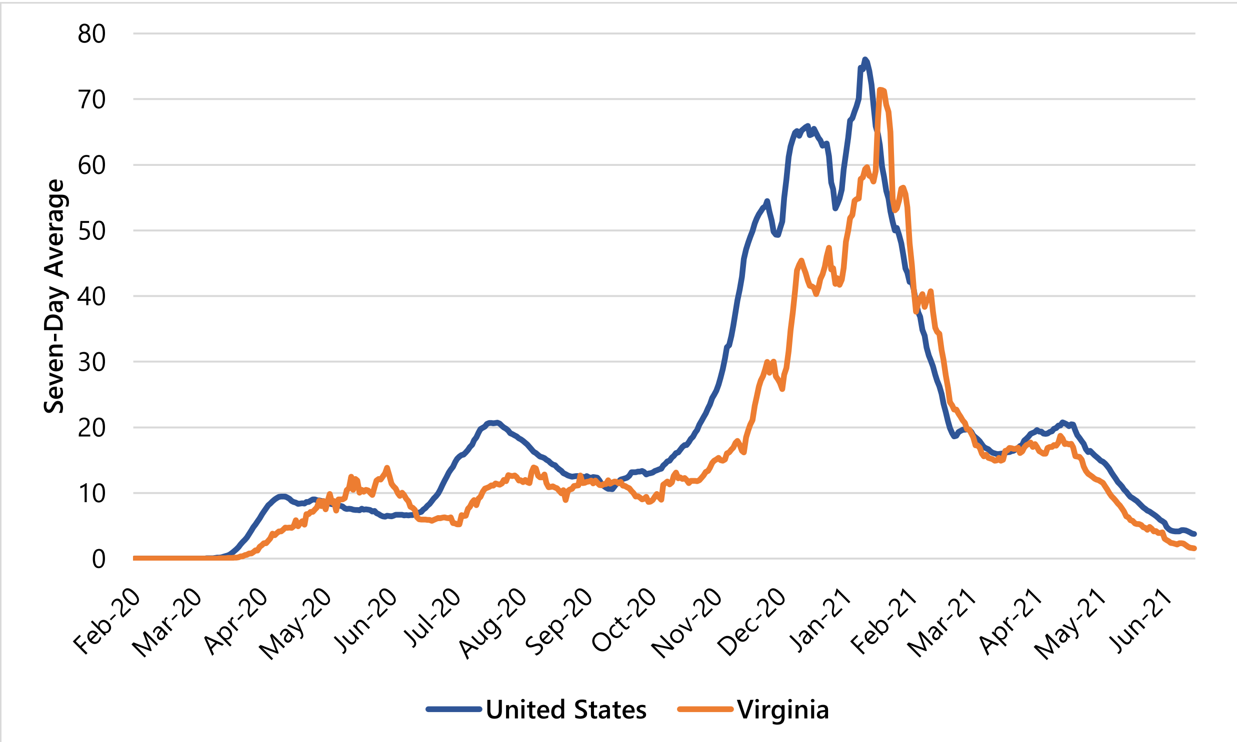
The report is divided into five sections. The first section describes the COVID-19 crisis and associated recession. The second section examines the effects of the recession on occupational employment patterns. The third section describes a methodology utilizing occupational-level survey information from O*NET and selected other data sources to identify occupations and CTE career clusters and pathways most likely to be vulnerable to the pandemic. The fourth section describes results from the analysis. The fifth section examines implications for CTE administrative planning and Comprehensive Local Needs Assessments.

2. The COVID-19 Recession: Economic and Labor Market Effects

The COVID-19 virus was first detected in the Wuhan province of China but rapidly spread to Europe, North America, and elsewhere through business and tourist travel. The first confirmed U.S. case occurred in Seattle on January 20, 2020. Just six weeks later, the federal government and most U.S. states began to impose numerous regulations to slow the pace of transmission, which had begun to result in large patient loads that overwhelmed local healthcare systems. From February 2020 to June 2021, the pandemic ebbed and flowed in three distinct waves (see **Figure 1**). The first wave began shortly before federal and state shutdown orders were instituted in March 2020. Clinical caseload surges were followed a few weeks later by corresponding upswings in COVID-19-related deaths, with older Americans, especially residents of long-term care facilities, particularly vulnerable to infection, severe morbidity, and mortality. The country experienced a brief lull in new infections and deaths in late spring, followed by a second wave of infections during active summer travel months after many states began to remove some COVID-19 restrictions. The third and largest wave began during the winter holiday season of 2020 and ebbed in the new year when immunization programs began to scale up.[1] Through June 15, 2021, at least 33 million U.S. residents had contracted the virus, and approximately 600,000 had died. In addition to direct loss of life, the U.S. experienced high "excess mortality" because of patients delaying preventive care and medical treatment due to fears of contracting the virus. Centers for Disease Control and Prevention (CDC) statistics indicate that the U.S. age-adjusted mortality rate jumped 16 percent from the year before to reach the highest level since 2003, reversing a long-term, 90-year trend of decreasing mortality rates over time (Kamp, Abbott, and Dapena 2021).

[1] Like the nation, Virginia experienced three infection waves through June 2021. However, these waves were somewhat less pronounced than the nation at large. On May 15, 2021, Virginia Governor Ralph Northam indicated that he was lifting social distancing and mask restrictions for those who had been fully vaccinated.

FIGURE 1: New COVID-19 Cases per 100,000 Residents, U.S. and Virginia, February 2020-June 2021



Source: Centers for Disease Control and Prevention COVID Data Tracker

In addition to the huge human costs in terms of loss of life and long-term symptoms in some survivors that have caused disability and reduced quality of life, the virus has exacted a high cost in terms of lost economic output and labor market disruption due to an ensuing recession. The recession was the consequence of both public efforts to contain and mitigate the pandemic and human fear of contracting the virus from other residents in public and workplace settings. Federal and state policies have been manifold and have included:

Stay-At-Home Orders. Members of the public were advised to shelter in place during the first wave of virus cases. In addition, throughout the pandemic, persons coming into contact with infected individuals or becoming infected themselves have often been required to quarantine for a period of time. These regulations have often been accompanied by restrictions on interstate and international travel.

Social Distancing Orders. Social distancing orders have been invoked that require residents and workers to maintain a certain physical distance (usually at least six feet) between themselves. This requirement is based on scientific evidence that the virus is most easily transmitted when individuals come into close contact.

PPE Requirements. Residents have been required to use Personal Protective Equipment (PPE), such as surgical or cloth masks or N95 ventilators, when going out in public and working with others. These requirements are based on scientific evidence that masking impedes the transmission of the virus from infected mask wearers and provides some degree of protection to noninfected individuals.

Suspension of Nonessential Business Activity. Early in the pandemic, federal and state governments identified businesses that were most essential to providing vital goods and services for hunkered-down households, such as medical care facilities, utilities, retail food stores, and pharmacies, and allowed them to remain open. Other nonessential businesses, such as clothing stores, restaurants, lodging, and personal services, were required to temporarily suspend operations.

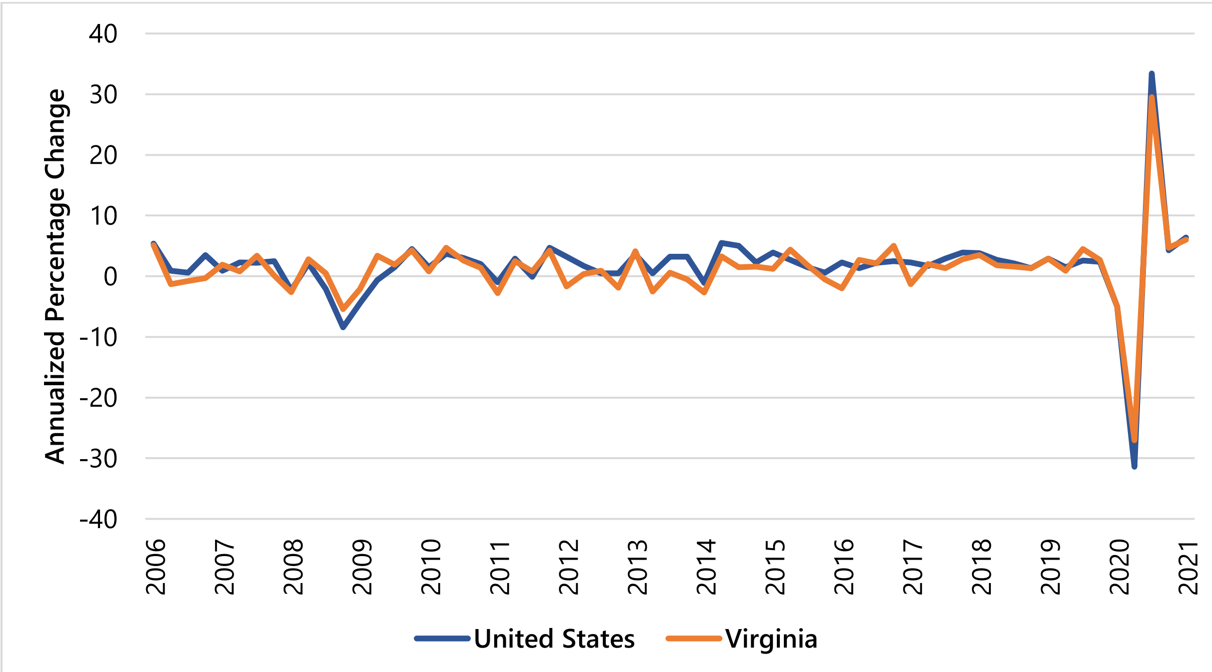
In addition to the state mandates, individuals and businesses have made their own decisions on how to minimize virus risks. Many businesses have purchased and utilized PPE, such as cashier shields, and have instituted other preventive measures, such as ventilation system improvements and regular deep-cleaning routines. In order to minimize worker exposure to the virus, adjust to workforce shortages, and better serve consumers, businesses have also increased efforts to automate business processes by introducing customer kiosks, ecommerce portals and apps, and workplace robots.

The COVID-19 pandemic precipitated an abrupt recession quite unlike any other recently experienced in the U.S. in terms of cause, depth, longevity, breadth, disparity of demographic impact, and policy response. To wit:

Cause. The previous two U.S. recessions were largely due to speculative financial "bubbles" in technology stocks and housing, while earlier ones were sometimes aggravated by energy market supply shocks. Often, more restrictive Federal Reserve monetary policy has preceded the downturns, contributing to erosion in durable goods spending and production that spreads to other sectors. The COVID-19 recession, in contrast, was precipitated by a pandemic and the government regulations implemented to slow the spread of the virus, resulting in the temporary closure of many service businesses, knock-on effects in other economic sectors, disruption of supply chains, plummeting consumer sentiment, and a drop in labor force participation due to caretaking responsibilities and fears of workplace infection. When the first COVID-19 wave conditions began to ease and social distancing regulations were relaxed in late April / early May 2020, consumer spending on retail goods and services began to recover.

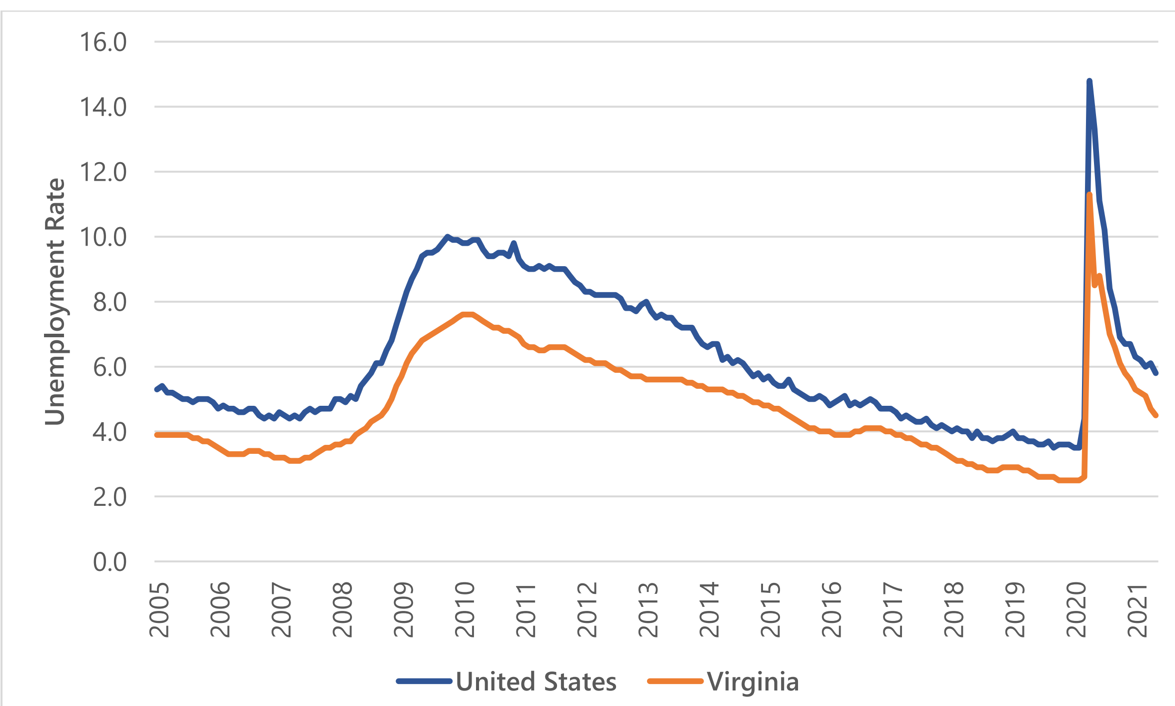
Depth. Economic activity started to decline during the first quarter of 2020, largely because of curtailment of economic activity in mid-March. However, second-quarter gross domestic product (GDP) dropped much faster, at an annualized rate of -31.4 percent, making it the largest quarterly drop in GDP in post-war history (Sigel and Van Dam 2020) (see **Figure 2**). The plunge in economic output was closely mirrored by the labor market. The unemployment rate shot up from a historically low rate of 3.5 percent in January 2020 to 14.8 percent in April 2020 (see **Figure 3**). During the same period, 22 million jobs were lost, a drop of 14.5 percent, with certain sectors, such as hotels and motels (38.6%), transportation (25.9%), and food services (25.6%), particularly hard-hit (Bureau of Labor Statistics 2020) (see **Table 1**).

FIGURE 2: Annualized Percentage Change in Real GDP by Quarter, U.S. and Virginia, 2006-2021



Source: Bureau of Economic Analysis, Quarterly GDP by State; real GDP in chained 2012 dollars

FIGURE 3: Unemployment Rate, U.S. and Virginia, 2005-2021



Source: Bureau of Labor Statistics; seasonally adjusted rates

TABLE 1: Change in Industry Employment, January 2020 to April 2020 and January 2020 to May 2021

	Percentage Change, January 2020-April 2020		**Percentage Change,** January 2020-May 2021	
Industry*	**Virginia**	**U.S.**	**Virginia**	**U.S.**
Construction	-5.3%	-14.2%	-2.1%	-2.5%
Education and health services	-11.4%	-11.4%	-3.9%	-4.1%
Financial activities	-2.9%	-2.9%	-3.9%	-0.5%
Government, federal	0.5%	1.1%	1.2%	1.2%
Government, state	-3.5%	-4.2%	-7.4%	-4.9%
Government, local	-4.9%	-5.4%	-7.5%	-6.1%
Information	-6.0%	-9.5%	-5.0%	-6.5%
Leisure and hospitality	-48.6%	-48.4%	-20.9%	-14.7%
Manufacturing	-7.6%	-10.8%	-2.7%	-3.9%
Mining and logging	-11.7%	-9.7%	-3.9%	-10.9%
Other services	-19.2%	-23.7%	-8.5%	-5.8%
Professional and business services	-4.7%	-11.0%	-1.0%	-3.2%
Retail trade	-14.4%	-15.2%	-1.4%	-2.6%
Transportation and utilities	-5.0%	-8.7%	3.6%	-1.3%
Wholesale trade	-4.9%	-7.0%	-3.4%	-3.7%
TOTAL	**-11.7%**	**-14.5%**	**-4.9%**	**-4.8%**

Source: U.S. Bureau of Labor Statistics; seasonally adjusted rates
**North American Industry Classification System (NAICS)*

Length. In addition to the economic recession being abrupt and deep, it was also exceptionally short[2] due to the nature of the pandemic (avian flu epidemics in East Asia have historically been characterized by sharp drop-offs and rapid recovery periods), modifications in household and business behavior in response to information about virus transmission and treatment that allowed some degree of normalcy to return, and the large size and rapid speed of federal policy response implementation. Economic activity snapped back after COVID-19 caseloads initially decreased and shutdown measures were relaxed. In early 2021, additional fiscal stimulus and widespread vaccination campaigns contributed to a dramatic drop-off in caseloads and provided considerable

[2] Recession lengths are determined by the National Bureau of Economic Research (NBER) Business Cycle Dating Committee, drawing on a variety of economic indicators such as real GDP, real income, employment, and industrial production measures. The typical recession lasts 22 months. On July 19, 2021, the committee announced that the COVID-19 recession, which began in February 2020, ended in April 2020, making it the shortest recession in U.S. history.

tailwinds to the economic recovery (Lang and Mena 2021).[3] Although most sectors have made up considerable lost ground, employment in some sectors, such as leisure and hospitality, state and local government, and mining, have continue to lag far behind pre-pandemic levels.

Federal Response. The federal government and Federal Reserve have applied unprecedented fiscal and monetary stimulus. Congress passed four pieces of major legislation between March and April of 2020 that provided an estimated $2.3 trillion in fiscal stimulus and relief (Coronavirus Preparedness and Response Supplemental Appropriations Act; The Families First Coronavirus Response Act; Coronavirus Aid, Relief, and Economic Security (CARES) Act; and Paycheck Protection Program and Health Care Enhancement Act). Among other provisions, this legislation offered loans to businesses (the Paycheck Protection Program or PPACA), extended and enhanced unemployment insurance benefits, provided aid to state and local governments, and made fiscal stimulus payments to individuals. The Congressional Budget Office (2020) estimated these programs would boost GDP by 4.7 percent in 2020 and 3.1 percent in 2021 compared to baseline forecasts. The Federal Reserve also took numerous actions to support businesses and households, including reducing its federal funds rate (a benchmark rate used in establishing other market interest rates), which was cut from 1.5 percent to 0 percent, reinstating quantitative easing securities purchases that were instituted to fight the previous recession, and instituting special lending programs for firms, financial institutions, and state and local governments that "helped unlock more than $2 trillion in funding" (Kiernan 2020). In late 2020 and early 2021, the Congress passed two additional fiscal stimulus and relief packages: a $900 billion COVID stimulus package (Coronavirus Response and Relief Supplemental Appropriations Act in December 2020) and the American Rescue Plan Act of 2021 ($1.9 trillion in March 2021). Altogether, the federal stimulus and relief packages amounted to over $5 trillion in fiscal stimulus, the largest fiscal stimulus package by far in U.S. history.

Breadth. Nearly every industry, region, and demographic has been affected in one way or another by the COVID-19 recession. Initially, the industries most affected by the crisis were those forced to close by state regulations, including nonessential retail trade, leisure and hospitality, and other services. However, the decrease in economic activity spilled over into other sectors of the economy. Moreover, some essential industries, such as food manufacturing, have been negatively impacted by supply chain impediments, including labor shortages caused by worker COVID illness and worker absences due to safety concerns. As the months have worn on, some sectors have proven to be especially resilient, creating a K-shaped recovery where some sectors

[3] As spring 2021 arrived, the country began to experience an economic boom, with resurgent consumer spending, widespread reports of supply chain problems, commodity and manufactured goods shortages (e.g., lumber, semiconductors), rising inflation pressures, and many businesses, particularly small businesses, reporting that they were unable to find workers. These labor shortages appeared to be related to lingering fears of workers returning to jobs due to health concerns, household difficulties finding childcare, and the relatively generous terms of unemployment benefits compared to lower-wage employment opportunities. Still, in May 2021, there were over 9 million more people still out of work than before the pandemic.

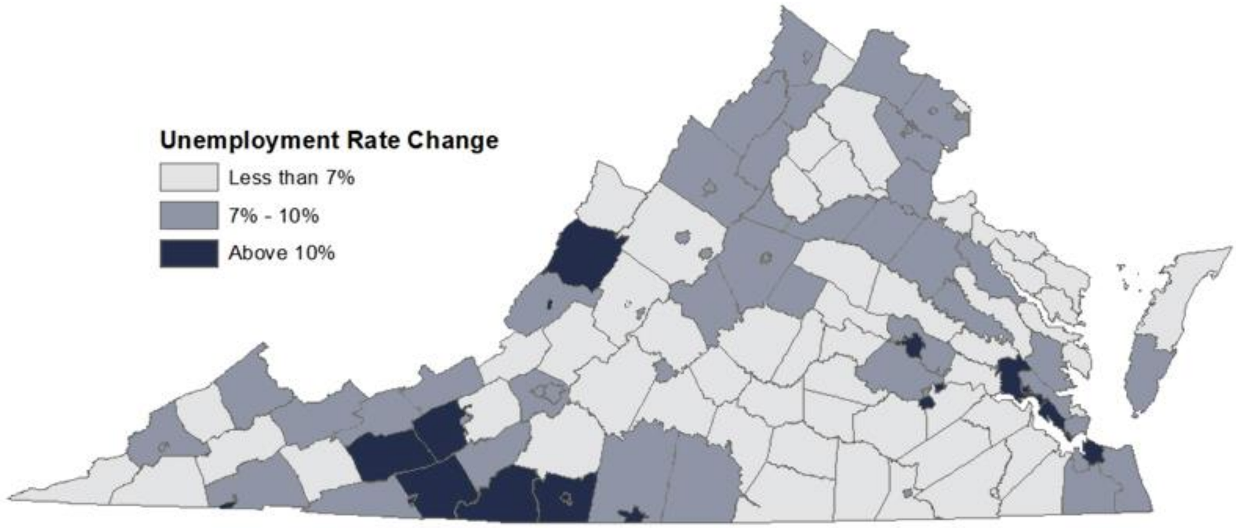
have bounced back and others have lagged behind (Morath, Francis, and Baer 2020). The goods sectors began to quickly recover because of pent-up consumer demand, accumulation of savings, fiscal stimulus, and lingering consumer apprehension about spending on services requiring closer personal contact. The housing sector has been buoyed by the combination of historically low mortgage interest rates and newfound interest in suburban and rural homeownership for working remotely and riding out the pandemic. Ecommerce has been supported by the consumer desire for social distancing. The regions and demographics hit particularly hard during the crisis have been those most concentrated in the affected service sectors. Regions reliant on leisure and hospitality and densely populated areas, such as central business districts, have experienced some of the largest contractions in business activity, while minorities, women, and lower-wage workers have experienced larger increases in unemployment.

Gender Disparity. Previous recessions disproportionately affected male employment due to higher male concentration in more cyclically sensitive, goods-producing industries (sometimes termed "Mancessions"). In contrast, the COVID-19 economic crisis has had a more deleterious impact on the female workforce, in part because females are more concentrated in service industries (leisure and hospitality, education, health services, and retail trade) that have been more severely affected. Nearly 13.4 million women lost their jobs in the initial months of the pandemic from February 2020 to April 2020 (-17.9%) compared to almost 12 million men (-14.7%). This gap was largely closed by late spring 2021. Supply explanation also accounts for the disparity in employment losses. Women traditionally assume more caregiving responsibilities, in particular the care of children—many of whom have been homebound and learning remotely due to widespread school closures—and the care of sick family members, including those who have contracted COVID-19. Women also constitute a larger share of workers in essential services, such as healthcare, where exposure to the virus has been much greater, leading to greater apprehension about exposure.

This experience has led some to speculate that future female employment participation and opportunities may be affected by changing patterns of employment and work organization. Slower long-term growth or job attrition in service industries where female employment has been concentrated may dampen future job opportunities. Some researchers have also found that women are more vulnerable to changes in occupational demand resulting from induced automation and social distancing (Chenroff and Warman 2020). The unusual caretaking burden caused by the pandemic may also cause women to shift into alternative career paths that "offer scheduling flexibility, have shorter commutes, or otherwise facilitate an increasingly complicated work-family balance" (Congressional Research Service 2020). On the other hand, the growth of telework offers some skilled female workers the possibility of greater flexibility in balancing home and work demands.

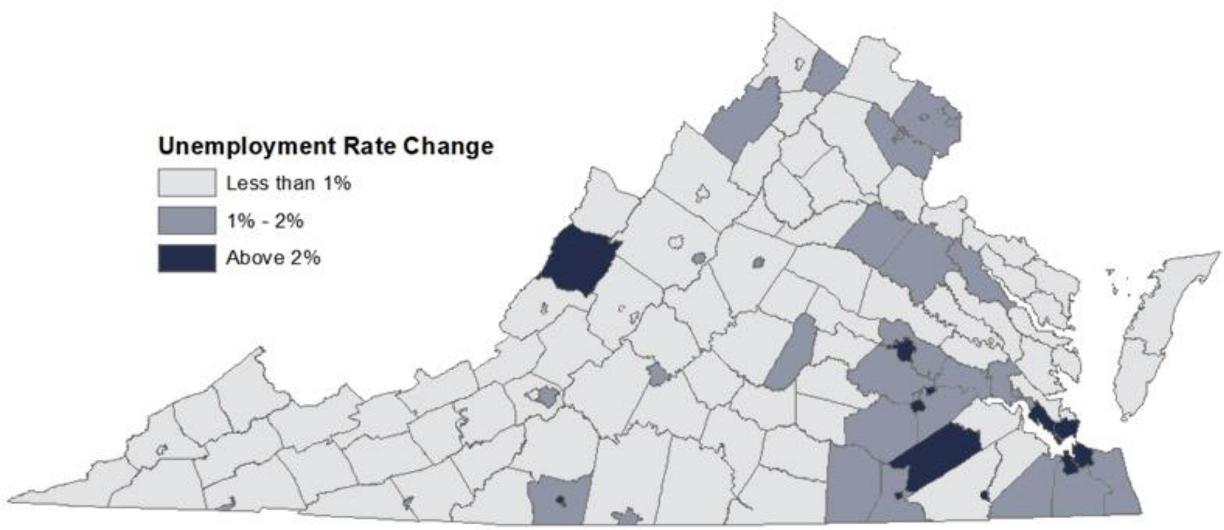
Effects on the Commonwealth Economy. Because of its greater reliance on industries less vulnerable to COVID-19 disruptions, such as federal government and business and professional services, the Commonwealth of Virginia experienced smaller decreases in economic output and employment over the same periods. However, the statewide picture, which is dominated by Northern Virginia, the Richmond-Petersburg metropolitan region, and Hampton Roads, masks considerable geographical variation in economic and employment outcomes. As **Figure 4a** illustrates, the drop in the seasonally unadjusted unemployment rate between January 2020 and April 2020 was widespread throughout the state, with clusters of particularly high unemployment impact in the Southside and Southwest regions, Richmond area, and Hampton Roads region. Areas particularly reliant on tourism, such as Bath County (Homestead Resort) and City of Williamsburg (Colonial Williamsburg and Busch Gardens), experienced some of the largest unemployment shocks (24% and 12% increases, respectively). Fast-forwarding to April 2021 (see **Figure 4b**), the situation had vastly improved; most Virginia counties' seasonally unadjusted unemployment rates were less than 1 percent higher than before the pandemic (nine localities actually had lower unemployment rates), and regional patterns were less distinct. However, the unemployment rate continues to lag in some independent cities that are more dependent on offices and service industries and in localities with large tourism sectors (e.g., Bath County, Williamsburg, and some other eastern parts of the state).

Figure 4a: Unemployment Rate Change by Locality, January 2020 to April 2020



Source: Virginia Employment Commission

Figure 4b: Unemployment Rate Change by Locality, January 2020 to April 2021



Source: Virginia Employment Commission

3. COVID Crisis Effects on Occupational Employment Patterns

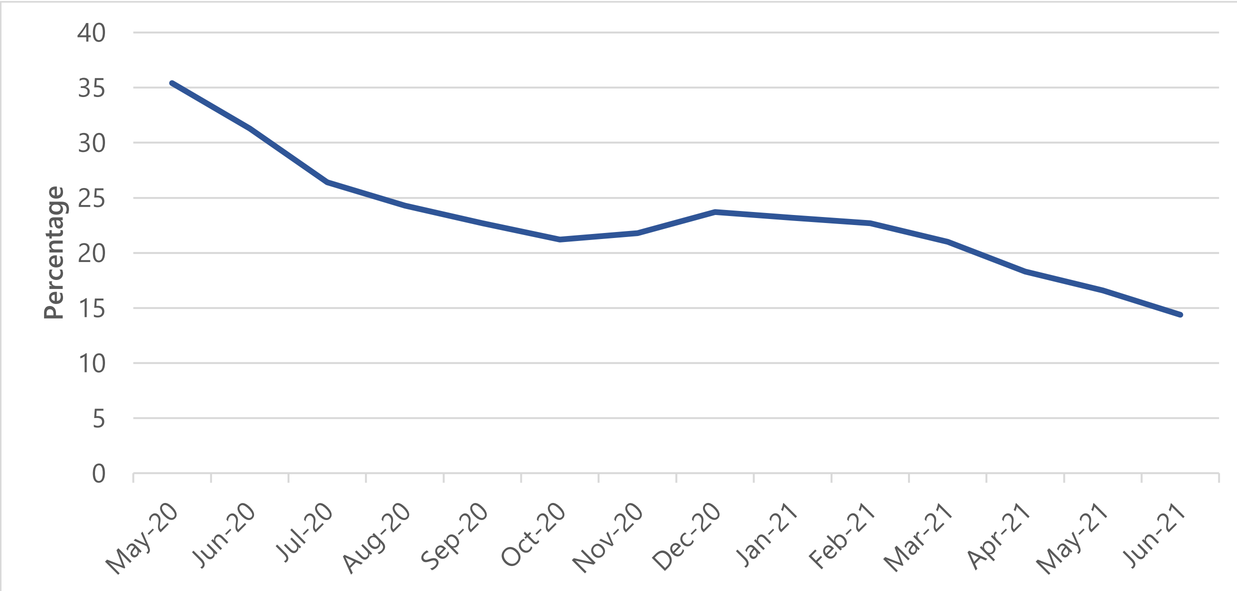
Recessions are typically periods of accelerated economic churn and change. Enterprises fail and new business models arise. Businesses introduce cost-cutting methods (such as offshoring of production) and adopt new technologies to preserve income when sales growth slows. Evidence suggests that the COVID-19 recession has had particularly profound disruptive effects on labor markets, some of which are likely to persist. According to Barrero et al. (2021), the pandemic induced job churning at double its pre-pandemic rate. They also cite firm-level forecasts that are predictive of continued churn, with employment growth trends favoring those industries where employees are better able to work from home.

As described previously, during the pandemic, industries and occupations requiring the highest physical proximity in the workplace (e.g., retail trade, personal services, leisure and hospitality) have been the most profoundly impacted. However, many economic researchers believe that disruptive forces observed during the pandemic have merely accelerated changes that were already present before the pandemic and that these forces will continue to shape the post-pandemic economic landscape due to changes in consumer and business attitudes, skills, and behaviors (McKinsey 2021; Autor and Reynolds 2020). According to these predictions and forecasts, changes in workplace organization to avoid close physical contact, such as greater automation of shopping and production tasks and remote and “hybrid work” (combining telecommuting with on-site work), have lasting staying power because of the added efficiency and flexibility they provide. McKinsey (2021) argues that three trends will shape the post-pandemic economy: (1) a significant increase in the percentage of workers who choose hybrid and teleworking arrangements; (2) faster growth in ecommerce and delivery services; and (3) more rapid adoption of workplace automation and digitization, such as robots and self-service kiosks.

Support for long-term shifts in these trends is provided below:

Teleworking/Hybrid Work. The social distancing required by the pandemic has forced workers in many industries and occupations to shift to remote work. This rushed arrangement has been described as a large unplanned "experiment," which has required workers to rapidly adapt to changing workplace conditions and find ways to make teleworking successful. Remote work has often forced employees to utilize new technologies, such as videoconferencing, business communication platforms, and document collaboration tools. At its peak, 35 percent of workers telecommuted due to the pandemic, with higher rates of 50 to 60 percent observed in information, financial activities, and professional and business services industries where close physical contact was less important (see **Figure 5**). This decreased to 14 percent for all employment by June 2021, after pandemic restrictions were lifted by states. In comparison, only 6 percent of U.S. residents worked primarily from home for all reasons in 2019 according to U.S. Census Bureau American Community Survey data (Coate 2021).

FIGURE 5: Percentage of Workers who Teleworked or Worked at Home Because of the Pandemic Within Four Weeks Prior to Being Surveyed, May 2020-June 2021



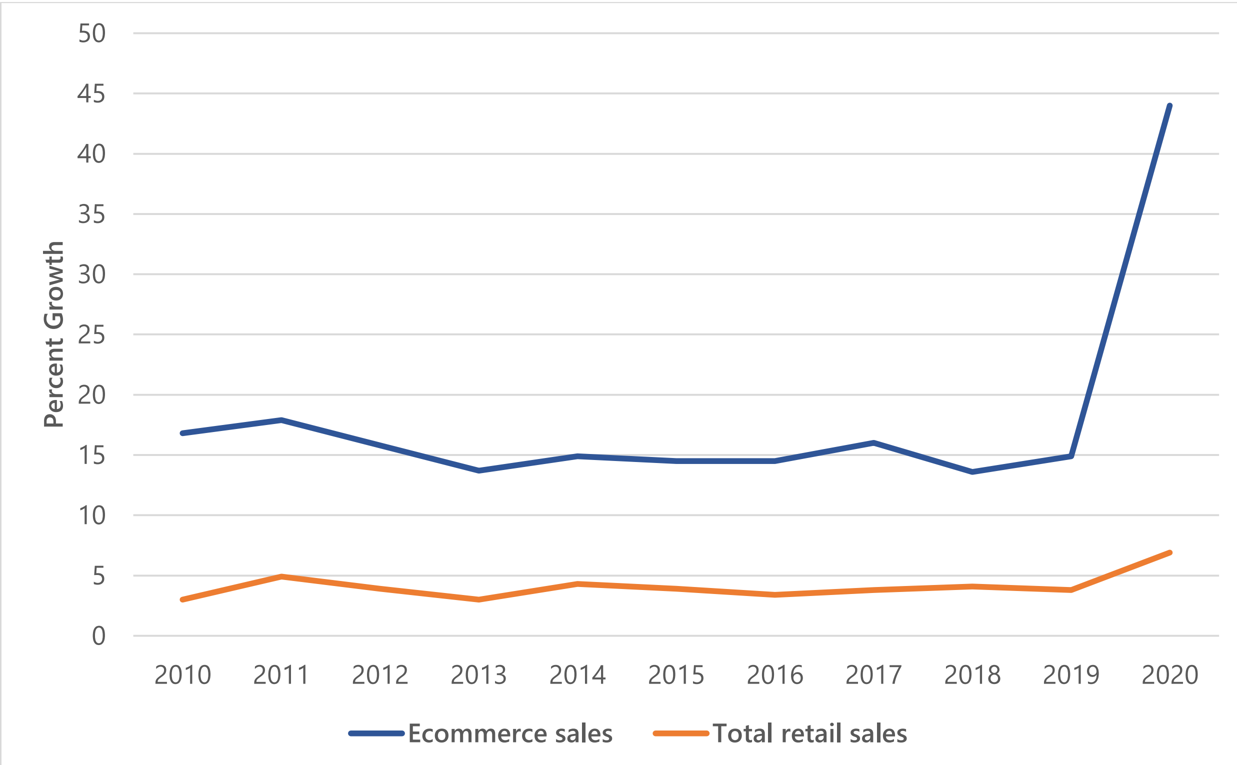
Source: Bureau of Labor Statistics, Current Population Survey; supplemental data measuring the effects of the coronavirus (COVID-19) pandemic on the labor market

Higher levels of remote working and blended hybrid work are likely to persist. Barrero, Bloom, and Davis (2020) identify five reasons for this. First, the pandemic has removed much of the "social stigma" of working from home and dispelled the perception that teleworkers are less effective. Second, many workers have found that they prefer to work from home and are more productive there. Third, firms and workers have invested considerable resources in training and equipment to accommodate the new teleworking arrangements. Fourth, innovation in technologies for working at home is rapidly growing and markets have only further expanded. Lastly, some workers may be reluctant to relinquish social distancing behaviors and work habits picked up during the pandemic.

Increased teleworking is likely to have significant ramifications for office space footprints across the country, with particular impact on city-center office and commercial districts. An August 2020 McKinsey survey of 278 executives indicated that executives planned to reduce office space by 30 percent on average (McKinsey 2021). This will reduce demand for support workers in other industries and professions, including food service and public transportation. According to Barrero, Bloom, and Davis (2020) data, workers have an even greater desire to work at home than their employers, preferring to spend 44 percent of their work hours at home compared to the 22 percent that employers are anticipating.

Ecommerce. Ecommerce has been growing at three times the rate of total retail sales over the last decade. However, the pandemic has forced many consumers to make greater use of digital tools. As a result, ecommerce transactions have grown seven times faster than total retail sales during the pandemic (see **Figure 6**). Many of these new ecommerce transactions have been among first-time users, with 75 percent of such consumers reporting they might continue using ecommerce after the pandemic (McKinsey 2021). Businesses have also shown increased enthusiasm for digital deployments. One survey of 800 business executives found that nearly half of companies plan to accelerate deployment of digital services for customers, such as ecommerce, mobile applications, and chatbots, and over a third will digitize supply chains (Lund et al. 2020).

FIGURE 6: Ecommerce Sales Growth Versus Total Retail Sales Growth, 2010-2020



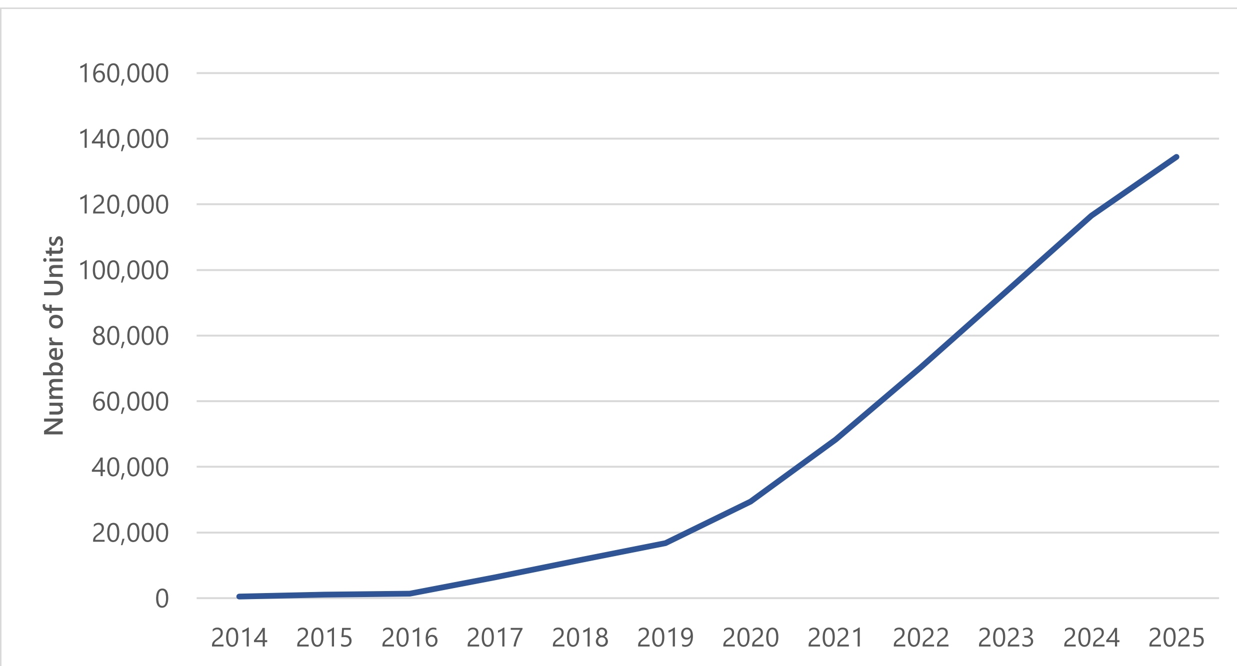
Source: Digital Commerce 360; U.S. Department of Commerce

Automation. The pandemic is expected to expedite company efforts to reduce workplace density through adoption of robots, deployment of consumer kiosks, and increased use of videoconferencing for teleworkers and business meetings that would have previously occurred on-site (McKinsey 2021). Sources of evidence for these automation trends include studies of previous recessions and pandemics, current surveys of business executives, and real-time data on spending.

Studies suggest previous recessions have led firms to hasten the pace of adopting labor-saving technologies, contributing to employment losses in occupations that involve routine workplace tasks (Jaimovich and Siu 2020; Hershbein and Kahn 2018). Recessions accelerate adoption by reducing the opportunity costs of investing in new technologies. Pandemics may provide additional impetus for these changes (Chernoff and Warman 2020). For example, a study of past major pandemics (SARS in 2003, H1N1 in 2009, Ebola in 2011, and MERS in 2021) found that robot installations increase after pandemics with a short lag, particularly when the economic and health impacts are more severe (Sedick and Yoo 2011). One motivation for these new automation investments is a desire to avoid workplace disruptions from potential future pandemics (Ding and Molina 2020). Ding and Molina (2020) found that automation accelerated during the current pandemic, with occupations at higher risk for automation experiencing greater employment decreases and lower resilience.

A 2020 McKinsey survey of 800 business executives found that 68 percent of executives plan to increase their use of automation (Lund et al. 2020). This also seems to be borne out by tangible, real-time data. First-quarter GDP data show that automation-related, private, fixed investment in computer equipment, software, and research and development rose by 42 percent, 11 percent, and 4 percent, respectively, from the year before, while GDP was flat (Cambon 2021). News reports indicate that U.S. factories, warehouses, and distribution centers have introduced more remote-operated forklifts, self-driving robots, and automated storage and retrieval systems to address workforce shortages and to satisfy increasing demand for goods (Smith 2021; Ip and Loten 2021). Business installation of cobots (or collaborative robots), which work with humans on workforce tasks in industrial settings, is projected to grow at an increasing rate (see **Figure 7**).

FIGURE 7: U.S. Collaborative Robots, Number of Units, Estimated and Projected, 2014-2025



Source: HMC Investment Securities

These trends in remote working, ecommerce, and automation are anticipated to have potent labor market impacts. McKinsey (2021) found that the largest short- and long-run impacts are likely to be felt in occupations requiring high levels of physical proximity and affected by greater automation, such as customer service for retail and hospitality industries, food services, office support, and jobs in industrial workspaces (see **Table 2**). Occupations that are less susceptible to automation, such as those in the healthcare and STEM fields, will see more job creation. Traditional bricks-and-mortar retail shops will likely continue to lose market share to ecommerce. Teleworking will negatively impact industries that provide services to commercial city centers, such as food services, building maintenance, and public transportation. These changes will require displaced workers to transition to occupational growth opportunities, many of which will require additional education and training.

Similar to the immediate recessionary effects of COVID-19, these long-term structural changes are expected to have uneven demographic, industrial, and geographical effects which exacerbate inequality. Greater job losses are expected for low-wage workers, women, racial/ethnic minorities, and urban centers, while many skilled professions will experience additional growth. The most negatively impacted jobs often involve routine activities and basic cognitive skills, while growing fields require more advanced technological and interpersonal skills.

TABLE 2: Shift in Employment due to COVID-19, 2018-30

Occupational Category	Difference in estimated net employment per 100,000 jobs	Estimated percentage point change in share of total employment
Agriculture	0.8	-0.1
Builders	6.5	-0.1
Business and legal professionals	0.3	0.2
Community services	7.9	-0.2
Creatives and arts management	1.3	0.2
Customer service and sales	-32.4	-1.1
Educator and workforce training	1.7	-0.1
Food service	-10.7	-0.7
Health aides, technicians, and care workers	8.1	2.2
Health professionals	6.5	1.2
Managers	3.2	0.6
Mechanical installation and repair	2.8	-0.2
Office support	-9.3	-2.6
Production and warehousing work	-0.5	-0.7
Property maintenance	-0.9	0.1
STEM professionals	6.9	1
Transportation services	7.6	0.3

Source: McKinsey (2021)

4. Measuring Occupational and CTE Program Sensitivity to COVID-19

As the pandemic was unfolding, several economic researchers attempted to gauge its occupational employment disruption potential by constructing measures of occupational vulnerability using information about features of jobs and workplaces (Albanesi and Kim 2020; Baker 2020; Chernoff and Warman 2020; Del Rio-Chanona et al. 2020; Dingel and Neiman 2020; Hicks, Faulk, and Davaraj 2020; Koren and Peto 2020; Mongrey, Pilossoph, and Weinberg 2020; Zhang 2020). **Appendix A** provides a brief summary of this literature and the ways that occupational data are used to measure occupational vulnerability. Although the metrics and methods used in these studies often differ, there are several commonalities. Areas of overlap include the following facets of occupations deemed to have affected workers' abilities to continue performing their jobs during the COVID-19 pandemic:

Disease Exposure. Industries and occupations where workers are more likely to be exposed to disease have been more likely to be disrupted. Such workers have been more likely to become ill, incapacitated, or die from COVID-19 exposure, and they may have been more reluctant to report to work because of workplace safety concerns and fears of transmitting the virus to other members of the household.

Critical Workforce. Being employed in a designated essential industry or in a profession regarded as critical has made a worker less vulnerable to layoff during the pandemic. Even workers who are not able to safely social distance (e.g., healthcare workers) have generally been required to report to work to provide vital goods and services.

Remote Work Potential. Workers able to work remotely (i.e., telework) can more easily remain socially distant from others while performing regular work activities productively and thus have been at lower risk of furlough.

Automation Risk. Some occupations have been at higher risk of displacement during the pandemic because they can be more easily automated. These occupations often involve performance of routine tasks, use of basic cognitive skills, or can otherwise be more easily performed by software or machines.

During the pandemic, disease exposure, critical workforce designation, teleworking potential, and automation potential have been significant occupational characteristics that have shaped employment outcomes. After the pandemic, disease exposure and essential industry designation will no longer be paramount factors shaping occupational employment patterns, though some residual effects might be expected. Based on previous analyses, however, such as those by McKinsey (2021) discussed in the previous section, there are reasons to expect that occupations will continue to be affected by long-term, structural trends favoring remote working and continued workplace automation.

Researchers generally measure occupational characteristics using data drawn from O*NET. O*NET is an occupational categorization system sponsored by the Employment and Training Administration of the U.S. Department of Labor based on survey data from employers and employees. It provides data for all Standard Occupational Classification (SOC) codes about characteristics of occupations, including knowledge and skills required by the occupation, tasks performed, and workplace characteristics.

To measure the occupational dimensions affecting work capability both before and after the pandemic, three widely cited pandemic studies providing publicly available data are referenced and utilized in this report. Chernoff and Warman (2020) used O*NET data to develop indices of ***disease exposure*** (i.e., viral transmission risk) and ***automation risk***. They relied on O*NET variables drawn from the work context, generalized work activities, and knowledge, skills, and abilities modules representing physical proximity, close contact, disease/infection exposure, outdoor work, and whether the tasks performed are routine, cognitive, manual, or analytical. Index construction methods used to generate the indices and validation of methods used to distinguish disease exposure and risk of automation are described more fully in **Appendix A** and in Chernoff and Warman (2020).

Dingel and Neiman (2020) created an O*NET-based measure of ***remote work potential***. To construct their index, they relied on 17 survey questions in the work context and generalized work activities O*NET modules described in **Appendix A**.[4] The measure was validated using expert assessment and was found to correlate with early pandemic estimates of the percentage of workers who worked remotely. The authors compute that 37 percent of U.S. workers have jobs that could be performed remotely.

The final dimension of pandemic occupational impact is a measure of an occupation's likelihood of being part of the ***critical workforce***. Cook (2020) used qualitative information in a Department of Homeland Security advisory list of essential infrastructure workers to construct a 2018 SOC list of occupations deemed "essential."[5] The authors estimated that 71 percent of U.S. workers are employed in the "Essential Critical Infrastructure Workforce."

In this study, the percentage of jobs vulnerable to pandemic-related employment disruption within each of Virginia's CTE career clusters and pathways based on each occupational risk attribute was computed using several intermediate pieces of information. First, thresholds were established to identify whether occupations are at higher risk for disruption or not. Critical workforce occupations were coded as "0" (lower risk of employment disruption) and nonessential occupations as "1" (higher risk of employment disruption). Using the Chernoff and Warman (2020) disease exposure and automation risk indices, any occupational index value above 0.5 was identified as involving greater-than-average viral transmission and automation risk and recoded as "1," with all others recoded as involving minimal risk, or "0." Based on the index

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[4] The Dingel and Neuman remote work potential computer code and data can be found at this URL: https://github.com/jdingel/DingelNeiman-workathome.

[5] The Cook occupational listing can be found at this URL: https://www.lmiontheweb.org/more-than-half-of-u-s-workers-in-critical-occupations-in-the-fight-against-covid-19/.

developed by Dingel and Neiman (2020), occupations were also characterized by whether they can be performed at home or not using the same binary classification (0=teleworkable or 1=work cannot be performed at home). To compute the Virginia CTE career cluster and pathway scores for each metric, the classification variables were weighted by the number of jobs in each occupation in Virginia using Virginia occupational employment data for 2018. Occupations were linked to Virginia Department of Education CTE career clusters and pathways using a crosswalk developed by the Weldon Cooper Center for Public Service. The resulting metrics represent the percentage of jobs within each CTE career cluster and pathway in Virginia that are vulnerable to pandemic-related employment disruption based on each occupational risk attribute.

Lastly, short-run and long-run measures of occupational, career pathway, and career cluster vulnerability to the pandemic were created by determining whether the percentage of jobs at risk within each CTE career pathway or cluster was greater than the percentage of jobs at risk among all occupations for each occupational risk attribute. For instance, if the percentage of jobs with automation risk in a particular CTE career cluster was greater than the percentage of all Virginia jobs with automation risk, the "automation risk" for that particular CTE career cluster was assigned a short-run vulnerability score of 1. By adding up all four occupational risk attribute scores, one obtains an overall measure of short-run occupational risk, with a minimum score of 0 and a maximum score of 4. After the pandemic, disease exposure and essential industry designation will no longer be as influential in shaping employment patterns; however, teleworking potential and automation will continue to be important. Therefore, the vulnerability scores for automation risk and remote work potential were added together to obtain a measure of long-run occupational risk, with a minimum long-run score of 0 and a maximum of 2.

Table 3 shows the results for the 17 Virginia CTE career clusters. It indicates that career clusters vary widely in terms of their anticipated short-term and long-term pandemic vulnerabilities. The *Marketing* cluster is exposed in both the short and long run. Occupations in the *Marketing* cluster are more likely to involve disease exposure, have limited remote work potential, be vulnerable to automation, and be designated as noncritical. Such occupations generally require a significant amount of face-to-face contact with coworkers and customers. Two other career clusters (*Law, Public Safety, Corrections, and Security* and *Human Services*) have also been under short-term pressure during the pandemic because of greater disease exposure, lower capacity for remote work, and lower likelihood to consist of occupations designated as essential. (The *Law, Public Safety, Corrections, and Security* cluster falls only slightly short in this last regard.) Long-term vulnerability of these two clusters, however, is lower. The four career clusters mainly at long-term risk because of lower remote work potential and greater automation risk are *Agriculture, Food, and Natural Resources; Architecture and Construction; Hospitality and Tourism;* and *Manufacturing*.

TABLE 3: COVID-19 Vulnerability by Virginia CTE Career Cluster and Occupational Risk Attribute, Short-Run and Long-Run

	Percentage of Jobs in Cluster				Vulnerability	
	High Disease Exposure	Not Critical Workforce	Limited Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
High Short- and Long-Run Vulnerability						
Marketing	78.2	53.0	72.6	73.2	4	2
High Short-Run Vulnerability						
Human Services	92.2	71.8	77.6	37.9	3	1
Law, Public Safety, Corrections, and Security	71.2	31.5	73.9	12.6	3	1
High Long-Run Vulnerability						
Agriculture, Food, and Natural Resources	33.0	10.7	85.3	61.6	2	2
Architecture and Construction	25.7	25.0	91.1	61.3	2	2
Hospitality and Tourism	57.2	28.7	96.8	90.4	2	2
Manufacturing	33.2	12.3	97.2	84.9	2	2
Low Short- and Long-Run Vulnerability						
Arts, Audio/Video Technology, and Communications	25.3	60.0	49.6	28.5	1	0
Business Management and Administration	68.9	49.4	15.2	33.5	2	0
Education and Training	88.2	10.7	3.7	1.1	1	0
Energy	44.5	27.9	98.5	44.3	1	1
Finance	38.4	28.2	16.8	52.9	1	1
Government and Public Administration	68.8	24.7	74.2	23.1	2	1
Health Science	97.4	9.5	89.3	24.0	2	1
Information Technology	47.5	0.0	0.0	42.8	0	0
Science, Technology, Engineering, and Mathematics	15.8	35.6	33.7	6.0	1	0
Transportation, Distribution, and Logistics	11.1	12.1	91.4	44.3	1	1

Source: Author's calculations based on multiple sources

Within some high-vulnerability career clusters can be found low-vulnerability career pathways; likewise, within some low-vulnerability clusters there are high-vulnerability career pathways. **Appendix B** provides a further breakdown of career pathway results by each of the 17 clusters.

Table 4-A shows a breakdown of "low-vulnerability" occupations (risk index equals zero), and **Table 4-B**, "high-vulnerability" occupations (risk index equals four), by CTE career cluster and labor market characteristic, such as predominant education level, nontraditional gender status, median annual wage, estimated number of Virginia jobs in 2018, and projected percent change in number of Virginia jobs by 2028.

Several patterns are evident. First, high-vulnerability occupations tend to be lower-paid and were projected to grow more slowly even before the pandemic. The unweighted median annual wage in 2018 for the 29 least vulnerable occupations was $94,130, and the weighted median was $106,253. The unweighted projected job growth rate for the same occupations was 6.4 percent, and the weighted average was 12.1 percent. In contrast, the 28 highest-vulnerability occupations paid an unweighted median annual wage of $39,049 and a weighted median of $28,242. The unweighted projected job growth rate for these high-vulnerability occupations was 6.0 percent, and the weighted average was 7.9 percent.

Educational and gender representation also differs between low- and high-vulnerability occupations. Although there are two exceptions, a bachelor's degree is the predominant educational level for less vulnerable vocations. For the 10 low-vulnerability occupations where data on gender representation are available, females are underrepresented in half, while 5 have more balanced gender representation. In contrast, some college or an associate degree is the predominant educational attainment for high-vulnerability occupations. Moreover, in the 14 high-vulnerability occupations where gender composition data are available, 8 are vocations where females are overrepresented in the workforce. These findings corroborate disparities in COVID-19 demographic impact described earlier and point to the importance of postsecondary degrees and promotion of nontraditional career paths for women to ensure lower short-term and long-term pandemic career risks and greater labor market success.

TABLE 4-A: Occupations with Low Vulnerability to COVID-19 Disruption

Virginia CTE Career Cluster	Virginia CTE Career Pathway	Occupational Title	Predominant Education Level	*Non-Traditional Gender Status	2018 Median Annual Wage-VA	Estimated Number of Jobs in 2018-VA	Projected Percent Change in Number of Jobs by 2028-VA
Agriculture, Food, and Natural Resources	Environmental Service Systems	Environmental Engineers	Bachelor’s	No Data	$85,269	1,308	3.4%
Agriculture, Food, and Natural Resources	Natural Resources Systems	Natural Sciences Managers	Graduate	No Data	$128,502	1,348	4.2%
Architecture and Construction	Design/Pre-Construction	Civil Engineers	Bachelor’s	Female	$89,603	11,310	6.4%
Arts, Audio/Video Technology, and Communications	Journalism and Broadcasting	Broadcast Technicians	Bachelor’s	No Data	$37,888	898	-3.2%
Arts, Audio/Video Technology, and Communications	Journalism and Broadcasting	Desktop Publishers	Some College/ Associate	No Data	$47,750	233	-14.6%
Arts, Audio/Video Technology, and Communications	Journalism and Broadcasting	Reporters and Correspondents	Bachelor’s	No Data	$40,208	845	-9.2%
Business Management and Administration	Business Information Management	Computer and Information Systems Managers	Bachelor’s	Neutral	$167,381	13,980	14.4%
Business Management and Administration	Operations Management	Purchasing Managers	Bachelor’s	Neutral	$136,015	2,968	6.0%
Education and Training	Administration and Administrative Support	Education Administrators, All Other	Graduate	No Data	$107,320	1,392	5.6%
Education and Training	Teaching/Training	Agricultural Sciences Teachers, Postsecondary	Graduate	No Data	(no data)	655	3.8%
Education and Training	Teaching/Training	Engineering Teachers, Postsecondary	Graduate	No Data	(no data)	828	10.6%
Education and Training	Teaching/Training	Geography Teachers, Postsecondary	Graduate	No Data	(no data)	213	4.2%
Education and Training	Teaching/Training	Physics Teachers, Postsecondary	Graduate	No Data	$74,118	400	6.0%
Education and Training	Teaching/Training	Political Science Teachers, Postsecondary	Graduate	No Data	(no data)	820	7.1%
Energy	Fuels Production	Petroleum Engineers	Bachelor’s	No Data	(no data)	179	-2.2%

Virginia CTE Career Cluster	Virginia CTE Career Pathway	Occupational Title	Predominant Education Level	*Non-Traditional Gender Status	2018 Median Annual Wage-VA	Estimated Number of Jobs in 2018-VA	Projected Percent Change in Number of Jobs by 2028-VA
Finance	Business Finance	Financial Specialists, All Other	Bachelor’s	No Data	$84,506	5,054	6.3%
Finance	Insurance	Insurance Underwriters	Bachelor’s	Neutral	$65,505	2,218	-2.4%
Government and Public Administration	Revenue and Taxation	Appraisers and Assessors of Real Estate	Bachelor’s	No Data	$58,318	1,904	8.1%
Human Services	Counseling and Mental Health Services	Industrial-Organizational Psychologists	Graduate	No Data	$128,743	328	13.4%
Information Technology	Information Support and Services	Computer Occupations, All Other	Bachelor’s	No Data	$106,665	16,023	8.6%
Information Technology	Network Systems	Computer Network Architects	Bachelor’s	Female	$123,504	10,000	13.7%
Information Technology	Network Systems	Information Security Analysts	Bachelor’s	Female	$110,470	14,561	45.4%
Information Technology	Programming and Software Development	Computer Programmers	Bachelor’s	Female	$94,161	7,639	-2.8%
Science, Technology, Engineering, and Mathematics	Engineering and Technology	Computer Hardware Engineers	Bachelor’s	Female	$122,873	1,463	13.9%
Science, Technology, Engineering, and Mathematics	Engineering and Technology	Electrical Engineers	Bachelor’s	No Data	$106,126	7,116	9.4%
Science, Technology, Engineering, and Mathematics	Engineering and Technology	Electronics Engineers, Except Computer	Bachelor’s	No Data	$115,405	5,126	7.7%
Science, Technology, Engineering, and Mathematics	Science and Mathematics	Atmospheric and Space Scientists	Bachelor’s	No Data	$106,370	345	12.5%
Transportation, Distribution, and Logistics	Logistics Planning and Management Services	Dispatchers, Except Police, Fire, and Ambulance	Some College/ Associate	Neutral	$39,780	5,368	2.9%
Transportation, Distribution, and Logistics	Logistics Planning and Management Services	Logisticians	Bachelor’s	Neutral	$82,651	8,156	7.8%

TABLE 4-B: Occupations with High Vulnerability to COVID-19 Disruption

Virginia CTE Career Cluster	Virginia CTE Career Pathway	Occupational Title	Predominant Education Level	*Non-traditional gender status	2018 Median Annual Wage-VA	Estimated Number of VA Jobs in 2018-VA	Projected Percent Change in Number of Jobs by 2028-VA
Arts, Audio/Video Technology, and Communications	Performing Arts	Actors	Bachelor's	No Data	(no data)	939	4.7%
Arts, Audio/Video Technology, and Communications	Printing Technology	Print Binding and Finishing Workers	HS Diploma	No Data	$38,100	1,299	-16.7%
Business Management and Administration	Administrative Support	Library Assistants, Clerical	Some College/ Associate	Male	$25,260	2,836	-2.7%
Business Management and Administration	Administrative Support	Receptionists and Information Clerks	Some College/ Associate	Male	$29,090	32,916	9.0%
Energy	Fuels Production	Continuous Mining Machine Operators	HS Diploma	No Data	$46,912	570	-11.8%
Health Science	Diagnostic Services	Diagnostic Medical Sonographers	Some College/ Associate	Male	$75,309	1,689	18.0%
Health Science	Diagnostic Services	Magnetic Resonance Imaging Technologists	Some College/ Associate	Neutral	$73,020	765	9.0%
Health Science	Diagnostic Services	Radiologic Technologists	Some College/ Associate	Neutral	$60,546	4,966	10.8%
Health Science	Support Services	Orderlies	Some College/ Associate	No Data	$28,455	937	6.3%
Health Science	Therapeutic Services	Dental Hygienists	Some College/ Associate	Male	$82,654	6,056	11.8%
Health Science	Therapeutic Services	Dietetic Technicians	Some College/ Associate	No Data	$32,364	436	6.4%
Health Science	Therapeutic Services	Radiation Therapists	Bachelor's	No Data	$76,753	599	6.0%
Hospitality and Tourism	Lodging	Hotel, Motel, and Resort Desk Clerks	Some College/ Associate	Male	$20,940	7,298	-5.2%
Hospitality and Tourism	Recreation, Amusements, and Attractions	Locker Room, Coatroom, and Dressing Room Attendants	Some College/ Associate	No Data	$22,242	230	14.8%

Virginia CTE Career Cluster	Virginia CTE Career Pathway	Occupational Title	Predominant Education Level	*Non-traditional gender status	2018 Median Annual Wage-VA	Estimated Number of VA Jobs in 2018-VA	Projected Percent Change in Number of Jobs by 2028-VA
Hospitality and Tourism	Travel and Tourism	Reservation and Transportation Ticket Agents and Travel Clerks	Some College/ Associate	Neutral	$38,420	4,724	7.7%
Human Services	Personal Care Services	Manicurists and Pedicurists	Some College/ Associate	Male	$23,501	5,217	16.8%
Human Services	Personal Care Services	Personal Care Aides	HS Diploma	Male	$20,332	42,865	36.9%
Human Services	Personal Care Services	Shampooers	Some College/ Associate	No Data	$21,117	1,306	17.0%
Human Services	Personal Care Services	Skincare Specialists	Some College/ Associate	Male	$34,441	1,694	16.6%
Law, Public Safety, Corrections, and Security	Security and Protective Services	Bailiffs	Some College/ Associate	No Data	$42,429	478	1.3%
Manufacturing	Maintenance, Installation, and Repair	Medical Appliance Technicians	Some College/ Associate	No Data	$40,013	248	10.9%
Manufacturing	Production	Cabinetmakers and Bench Carpenters	HS Diploma	Female	$34,971	3,199	-4.2%
Manufacturing	Production	Dental Laboratory Technicians	Some College/ Associate	No Data	$49,341	1,055	10.1%
Manufacturing	Production	Photographic Process Workers and Processing Machine Operators	Bachelor’s	No Data	$24,885	443	-14.4%
Manufacturing	Production	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	HS Diploma	No Data	$28,373	2,499	4.0%
Marketing	Professional Sales	Counter and Rental Clerks	HS Diploma	Neutral	$29,459	13,068	2.3%
Marketing	Professional Sales	Retail Salespersons	Some College/ Associate	Neutral	$24,217	107,474	-1.3%
Transportation, Distribution, and Logistics	Transportation Operations	Bus Drivers, School or Special Client	HS Diploma	No Data	$31,171	19,051	2.7%

Source: University of Virginia Weldon Cooper Center for Public Service, CTE Trailblazers Labor Market Data

5. Implications for CTE Planning and Comprehensive Local Needs Assessments

CTE experts suggest that COVID-19 will necessitate future adjustments to educational delivery, professional development, career counseling, and program planning (ACTE 2020; Kramer and Kramer 2020). Many school divisions were not prepared for the pandemic with appropriate digital media, online learning tools, and take-home kits. Moreover, some students, particularly disadvantaged students, do not have the proper home equipment (e.g., personal computers, broadband access) and mentoring needed for effective virtual learning. Pandemic-imposed limitations have been particularly burdensome for CTE students because of the requisite lab, clinical, and workplace experience components that are vital to student experiential learning and skills acquisition. This experience suggests that greater incorporation of blended learning, simulation training software, and other digital tools may need to become more regular complements to in-class learning. Making optimal use of these instructional tools will require enhanced professional development for teachers and counselors in using learning management systems and videoconferencing platforms and in creating engaging and challenging content. In an economy where teleworking and hybrid work is likely to become more prevalent, blended instruction could potentially be used as a tool to prepare students for remote work.

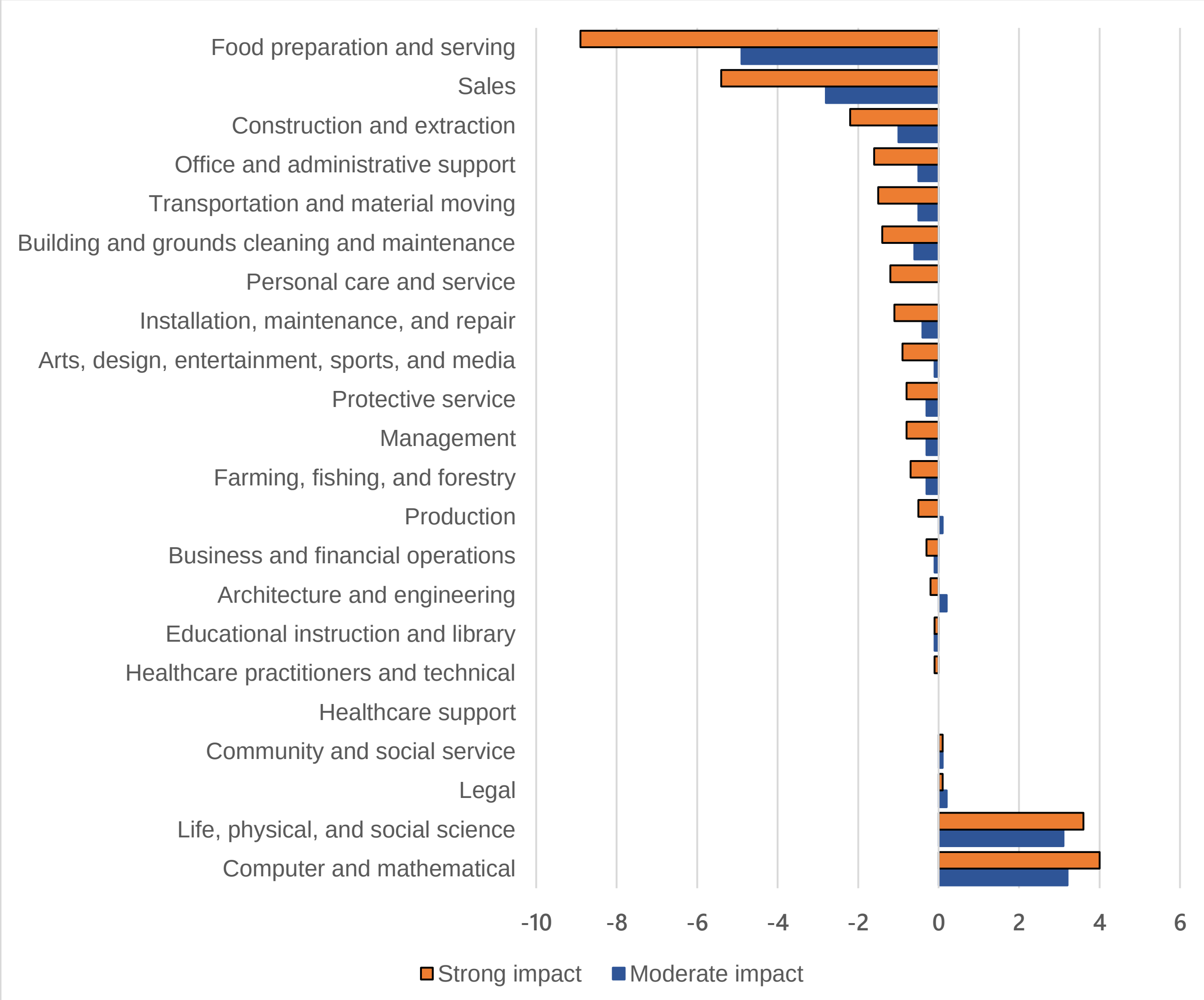
Some adjustments may also be needed in career counseling. The pandemic is expected to continue to exert a significant effect on labor markets, with adverse effects on some occupations and career paths and positive effects on others. Those likely to be negatively impacted tend to offer limited potential for remote work, greater likelihood of being automated, more exposure to health risks, lower wages, and poor working conditions (Kramer and Kramer 2020). Job security is another occupational element that may be important to present to students when making career choices (Arnholz 2021).

The most effective job preparation is aligned to employer needs and adapts to changes in the economy and labor markets. Changes in local labor markets caused by the pandemic will need to be addressed in Comprehensive Local Needs Assessments required as part of Perkins V reporting. Virginia CTE administrators have traditionally relied on occupational projections released by the Bureau of Labor Statistics (BLS) and Virginia Employment Commission (VEC) in determining occupations and career clusters and pathways with the greatest growth potential. Occupational projections for the 2018-2028 period used in the latest Trailblazers labor market data analyses were released prior to the pandemic. Current BLS state occupational projections for the 2019-2029 period were developed during the early stages of the pandemic but also did not yet incorporate the effects of the crisis into the results (Dubrina, Kim, Rolen, and Rieley 2020). BLS occupational projections for the period 2020-2030, which will be released in fall 2021, are expected to incorporate such effects. Unfortunately, regional labor market data reflecting pandemic effects within Virginia’s Local Workforce Development Areas (LWDAs) are not likely to be available until summer 2023, based on previous data release timing.

In the meantime, BLS has developed a set of alternative projections for the 2019-2029 period to estimate the potential impact of COVID-19 on occupational employment projections (Ice, Rieley, and Rinde 2021). These projections represent an initial attempt to understand how pandemic effects might affect industries and occupations differently from earlier-released 2019-2029 baseline projections. The projections are built upon two scenarios. The first impact scenario ("Moderate") assumes a modest increase in the percentage of workers who telework and utilize videoconferencing for business meetings instead of business travel. The second impact scenario ("Strong") assumes that teleworking expands further, and consumers lessen their contact with others in stores and businesses by utilizing ecommerce, consumer kiosks, and phone apps and by consuming fewer indoor food establishment, entertainment, and tourism services. The results of these scenarios are presented in **Figure 8**.

Under each scenario, results indicate that food services, sales, office and administrative support, buildings and grounds maintenance, and transportation and materials moving are likely to be most negatively impacted relative to baseline projections. Information technology and STEM will see the largest positive impacts, with healthcare, social services, and educational services adjusting close to baseline projections. The ordering of vocations likely to be impacted by the pandemic in the alternate 2019-2029 BLS projections is largely consistent with findings presented elsewhere in this report.

FIGURE 8: Pandemic Occupational Employment Impacts, 2019-2029



Source: Ice, Rieley and Rinde (2020)
Note: Difference in percentage changes between baseline BLS and alternate (moderate/strong) pandemic impact scenarios

Research for this report suggests that two of Virginia's CTE career clusters are particularly vulnerable to short-run pandemic effects—*Human Services* and *Law, Public Safety, Corrections, and Security*; four are vulnerable to long-run effects—*Agriculture, Food, and Natural Resources; Architecture and Construction; Hospitality and Tourism;* and *Manufacturing*; and one—*Marketing*— is susceptible to both short- and long-run effects. Because factors more influential in the short run, such as disease exposure and essential industry classification, are already becoming less important in shaping employment trends as the pandemic progresses, focusing on the long-run vulnerability of occupations is likely to be more relevant to long-range CTE administrative planning. CTE career clusters and pathways consisting of occupations with high long-run occupational vulnerability (higher-than-average risk exposure to future job automation and lower-than-average capability for remote work) are listed below.

CTE Career Clusters and Pathways with High Long-Run Occupational Vulnerability

CLUSTERS

- Agriculture, Food, and Natural Resources
- Architecture and Construction
- Hospitality and Tourism
- Manufacturing
- Marketing

PATHWAYS

- Agriculture, Food, and Natural Resources
    - Animal Systems
    - Food Products and Processing Systems
- Architecture and Construction
    - Construction
    - Maintenance/Operations
- Arts, Audio/Video Technology, and Communications
    - Printing Technology
- Energy
    - Fuels Production
    - Power Generation
- Finance
    - Banking Services
- Government and Public Administration
    - National Security
- Health Science
    - Diagnostic Services
- Hospitality and Tourism
    - Lodging
    - Restaurants and Food/Beverage Services
    - Travel and Tourism
- Human Services
    - Personal Care Services
- Manufacturing
    - Logistics and Inventory Control
    - Maintenance, Installation, and Repair
    - Production
    - Quality Assurance
- Marketing
    - Merchandising
    - Professional Sales
- Transportation, Distribution, and Logistics
    - Warehousing and Distribution Center Operations

In response to potential occupational vulnerabilities to future automation, CTE administrators and instructors may want to consider expanding curricular exposure to new and emerging technologies in introductory courses. Additionally, it will be imperative that students are kept up-to-date on the latest automation trends within specific occupations to be certain they are being taught skills that will prepare them to work with and alongside the latest technologies in their chosen fields. Training in these more specific skill sets might best be incorporated into higher-level CTE courses or Work-Based Learning experiences that are focused on preparing students for specific career fields or occupations. And last, but certainly not least, workplace readiness skills that help students prepare to adapt to changing workplace conditions in the future—such as critical thinking, problem-solving, continuous learning, and adaptability—should continue to be emphasized and integrated into CTE course curricula.

Concern about pandemic effects on future occupational growth should also be balanced by the forecasted job outlook for each occupation aside from any pandemic-related effects. For example, two occupations in the *Animal Systems* pathway identified as having long-run pandemic-related risk exposure—*Veterinary Technologists and Technicians* and *Veterinary Assistants and Laboratory Animal Caretakers*— are also expected to grow by about 34 percent through 2028, placing them among the top five fastest-growing occupations in Virginia.

Labor market assessments developed before the pandemic may need to be reevaluated for currency and relevancy in the post-pandemic environment to ensure that program and course offerings align with business and industry labor market needs (Vankudre and O'Kane 2020; ACTE 2020). Also, the temporary absence of occupational projections that reflect COVID-19 impacts may mean local decision makers need to place more weight on employer feedback, employer surveys, real-time labor market analytics, and other information, such as the analysis of COVID effects included in this report, until a clearer picture emerges from occupational projections more reflective of COVID-19-induced changes when they are released in the next two years.

APPENDICES

APPENDIX A
O*NET OCCUPATIONAL PANDEMIC VULNERABILITY MEASURES

O*NET classifications have been used in at least a dozen different studies in the last decade to measure several occupational vulnerabilities similar to those used in this report. Blinder (2007) was one of the first studies to use O*NET survey data to characterize the potential changes to occupational labor markets resulting from economic disruption, in this case offshorability of work resulting from increased global trade. The study used O*NET data to aid in assigning two-digit index scores for the offshorability of each occupation. Frey and Osborne (2017) developed an index that showed how resistant different occupations were to automation utilizing seven O*NET questions reflecting social intelligence, creativity, and physical dexterity; subjective assessments of a sample of 70 occupations susceptible to automation; and a machine learning classification technique.

The COVID-19 crisis led to a deluge of studies attempting to gauge the potential differential impact of the pandemic on industries and occupations. It quickly became apparent to researchers that O*NET was a veritable treasure trove of data that could be used to characterize occupational risk. Studies measured various facets of occupational vulnerability resulting from pandemic disruption in the workplace, including viral exposure (Chernoff and Warman 2020; Zhang 2020), ability to social distance (Hicks, Faulk, and Davaraj 2020), remote work potential (Baker 2020; Del Rio-Chanona et al. 2020; Dingel and Neiman 2020), and automation potential. **Table A-1** describes the study, feature, and research methodology used in developing each measure.

Among studies addressing the same COVID-19 occupational dimensions, there is some degree of overlap in relation to the O*NET surveys, variables, and index construction methods used. Studies measuring social distancing, disease exposure, and remote working potential generally rely on the O*NET Generalized Work Activities (WA) and Work Context (WC) questions. For example, Mongey, Pilossoph, and Weinberg (2020) used the same variables to measure social distancing potential as Dingel and Neiman (2020) used for remote work potential, albeit utilizing a different normalization method. Albenesi and Kim (2021) used 15 of the 17 measures used by Dingel and Neiman (2020) in constructing their remote work measure. However, there are significant differences in individual concepts. For example, many vocations (e.g., farming, construction) cannot be performed remotely but allow social distancing and facilitate low disease exposure. There are fewer studies and greater heterogeneity in how researchers define automation potential. In addition to the WA and WC modules, some of these studies utilize information from the Knowledge (K), Skills (S), and Abilities (A) modules.

Many of these studies validated their measures with other public or expert data. Dingel and Neiman (2020) found that their O*NET classification had a high correlation with subjective assessments of telework potential and early pandemic estimates of the percentage of workers who worked remotely. Mongey, Pilossoph, and Weinberg (2020) showed that their remote-working measure was highly correlated with occupational information on working from home derived from the American Time Use Survey (ATUS). Albanesi and Kim (2021) found that their O*NET measure of automation correlated with another popular routine-task intensity automation measure developed by Autor and Dorn (2013).

Several studies have also developed lists of essential industries. None of these depend on O*NET survey data but were derived from government descriptions of industries or occupations deemed essential, critical, or important during the early stages of the COVID-19 crisis. Del Rio-Chanona (2020) based their list of essential industries on an Italian government list that was crosswalked to U.S. SOC codes. Tomer and Kane (2020) developed a list of essential infrastructure industries based on a Cybersecurity & Infrastructure Security Agency guidance memorandum on essential critical infrastructure workers. Cook (2020) mapped the same list to 6-digit SOC occupations.

TABLE A-1: Studies Utilizing O*NET Data Relevant to Constructing Pandemic Occupational Risk Measures

Source	Construct(s)	Description
Albanesi and Kim (2020)	Remote Work Potential, Social Distancing, and Automation	Authors used 15 O*NET questions to identify occupations where work can be performed remotely. Contact intensity and automation potential were identified using one O*NET variable each.
Baker (2020)	Remote Work Potential	Authors characterized occupations that are more difficult to conduct from home using two O*NET survey measures.
Chernoff and Warman (2020)	Viral Exposure Risk and Automation	Authors developed a viral transmission risk index based on five O*NET variables related to workplace physical proximity and outdoor work. Their automation risk index uses 16 variables reflecting whether work revolves around routine, manual, or analytical tasks. They classified high-risk occupations as those where both indexes are greater than or equal to 0.5.
Del Rio-Chanona et al. (2020)	Remote Work Potential	Authors developed a remote work index based on an O*NET list of 332 possible “Intermediate Work Activities” combined with subjective assessment of whether a job could be performed at home.
Dingel and Neiman (2020)	Remote Work Potential	Authors classified feasibility of working at home using 15 O*NET questions addressing physical and social factors influencing work and types of job behaviors involved.

Source	Construct(s)	Description
Frey and Osborne (2017)	Automation	Authors created an index of how resistant different occupations are to automation using responses to seven O*NET questions reflecting social intelligence, creativity, and physical dexterity. Research utilized subjective assessments of a sample of 70 occupations' susceptibility to automation, O*NET data, and a machine learning classification technique to classify all occupations.
Hicks, Faulk, and Devaraj (2020)	Social Distancing	Authors identified occupations where social distancing is difficult using two O*NET variables. They identified such occupations as those in the top half of each distribution.
Koren and Peto (2020)	Social Distancing	Authors developed a social distancing index reflecting communication intensity with coworkers and customers and importance of physical presence based on 14 O*NET variables.
Mongey, Pilossoph, and Weinberg (2020)	Remote Work Potential and Social Distancing	Authors used Dingel and Neiman's (2020) 17 O*NET variables to identify occupations that can be performed remotely but constructed the index differently. Physical proximity index is based on O*NET workplace physical proximity variable.
Zhang (2020)	Viral Exposure Risk	Authors used multiple regression analysis to demonstrate that the O*NET variables "exposed to disease or infections" and "physical proximity" are associated with occupational COVID-19 case counts in Washington State and explain nearly half of case prevalence by occupation.

APPENDIX B

COVID-19 VULNERABILITY BY VIRGINIA CTE CAREER CLUSTER AND PATHWAY

TABLE B-1: Vulnerability by Occupational Attribute; Agriculture, Food, and Natural Resources

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Agriculture, Food, and Natural Resources	33.0	10.7	85.3	61.6	2	2
Pathways						
Agribusiness Systems	0.0	0.0	100.0	0.0	1	1
Animal Systems	100.0	0.0	100.0	69.8	3	2
Environmental Service Systems	0.0	24.2	66.1	34.7	1	1
Food Products and Processing Systems	35.3	0.0	100.0	91.6	2	2
Natural Resources Systems	0.0	13.8	65.0	43.5	1	1
Plant Systems	0.0	100.0	77.2	0.0	2	1
Power, Structural, and Technical Systems	0.0	0.0	100.0	0.0	1	1

TABLE B-2: Vulnerability by Occupational Attribute; Architecture and Construction

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Architecture and Construction	25.7	25.0	91.1	61.3	2	2
Pathways						
Construction	24.9	19.9	100.0	49.4	2	2
Design/Pre-Construction	6.7	59.3	6.2	14.0	1	0
Maintenance/Operations	30.4	22.7	100.0	81.8	2	2

TABLE B-3: Vulnerability by Occupational Attribute; Arts, Audio/Video Technology, and Communications

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Arts, Audio/Video Technology, and Communications	25.3	60.0	49.6	28.5	1	0
Pathways						
Audio/Video Technology and Film	66.7	22.3	23.8	61.9	2	1
Journalism and Broadcasting	32.3	73.7	9.6	30.0	1	0
Performing Arts	24.5	55.5	81.1	31.7	2	1
Printing Technology	32.5	100.0	88.3	100.0	3	2
Telecommunications	0.0	0.0	100.0	0.0	1	1
Visual Arts	27.4	100.0	8.7	2.9	1	0

TABLE B-4: Vulnerability by Occupational Attribute; Business Management and Administration

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Business Management and Administration	68.9	49.4	15.2	33.5	2	0
Pathways						
Administrative Support	88.2	32.0	24.4	56.8	3	1
Business Information Management	0.0	0.0	0.0	0.0	0	0
General Management	77.1	77.1	3.3	0.0	2	0
Human Resources Management	83.6	42.3	0.0	14.9	2	0
Operations Management	3.9	93.2	5.1	0.0	1	0

TABLE B-5: Vulnerability by Occupational Attribute; Education and Training

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Education and Training	88.2	10.7	3.7	1.1	1	0
Pathways						
Administration and Administrative Support	89.3	0.0	8.3	0.0	1	0
Professional Support Services	91.9	39.7	15.9	10.6	2	0
Teaching/Training	87.7	7.7	1.8	0.0	1	0

TABLE B-6: Vulnerability by Occupational Attribute; Energy

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Energy	44.5	27.9	98.5	44.3	1	1
Pathways						
Energy Sustainability and Efficiency	0.0	100.0	100.0	0.0	2	1
Energy Transmission, Distribution, and Storage	86.5	0.0	100.0	32.4	2	1
Fuels Production	47.1	73.6	85.1	58.7	3	2
Power Generation	0.0	0.0	100.0	100.0	2	2

TABLE B-7: Vulnerability by Occupational Attribute; Finance

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Finance	38.4	28.2	16.8	52.9	1	1
Pathways						
Accounting	11.8	43.9	3.4	56.1	2	1
Banking Services	53.5	0.0	74.5	69.2	2	2
Business Finance	85.9	0.0	0.0	11.7	1	0
Insurance	42.0	42.8	1.3	88.9	2	1
Securities and Investments	58.9	41.1	11.5	19.2	2	0

TABLE B-8: Vulnerability by Occupational Attribute; Government and Public Administration

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Government and Public Administration	68.8	75.3	25.8	23.1	2	0
Pathways						
Foreign Service	--	--	--	--	--	--
Governance	0.0	100.0	100.0	0.0	2	1
National Security	100.0	0.0	100.0	100.0	3	2
Planning	100.0	100.0	100.0	0.0	3	1
Public Management and Administration	100.0	100.0	59.4	86.4	3	1
Regulation	71.1	2.0	75.2	2.0	2	1
Revenue and Taxation	0.0	48.9	48.9	48.9	1	0

TABLE B-9: Vulnerability by Occupational Attribute; Health Science

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Health Science	97.4	9.5	89.3	24.0	2	1
Pathways						
Biotechnology Research and Development	100.0	0.0	0.0	0.0	1	0
Diagnostic Services	100.0	48.9	99.4	85.9	4	2
Health Informatics	69.2	11.5	5.1	62.9	2	1
Support Services	100.0	26.1	96.3	27.7	2	1
Therapeutic Services	100.0	6.2	97.5	16.3	2	1

TABLE B-10: Vulnerability by Occupational Attribute; Hospitality and Tourism

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Hospitality and Tourism	57.2	28.7	96.8	90.4	2	2
Pathways						
Lodging	25.5	25.5	100.0	97.3	2	2
Recreation, Amusements, and Attractions	97.9	100.0	26.1	16.4	2	0
Restaurants and Food/Beverage Services	57.8	24.2	100.0	93.7	2	2
Travel and Tourism	77.9	100.0	100.0	77.9	4	2

TABLE B-11: Vulnerability by Occupational Attribute; Human Services

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Human Services	92.2	71.8	77.6	37.9	3	1
Pathways						
Consumer Services	100.0	100.0	0.0	100.0	3	1
Counseling and Mental Health Services	95.6	34.5	41.4	0.0	2	0
Early Childhood Development and Services	100.0	100.0	0.0	0.0	2	0
Family and Community Services	88.4	8.2	81.0	0.0	2	1
Personal Care Services	91.3	90.3	95.9	60.3	4	2

TABLE B-12: Vulnerability by Occupational Attribute; Information Technology

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Information Technology	47.5	0.0	0.0	42.8	0	0
Pathways						
Information Support and Services	49.7	0.0	0.0	63.5	1	1
Network Systems	14.1	0.0	0.0	51.6	1	1
Programming and Software Development	65.0	0.0	0.0	27.9	1	0
Web and Digital Communications	0.0	0.0	0.0	100.0	1	1

TABLE B-13: Vulnerability by Occupational Attribute; Law, Public Safety, Corrections, and Security

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Law, Public Safety, Corrections, and Security	71.2	31.5	73.9	12.6	3	1
Pathways						
Correction Services	100.0	13.2	86.8	0.0	2	1
Emergency and Fire Management Services	98.4	1.2	100.0	12.7	2	1
Law Enforcement Services	100.0	1.8	97.5	0.0	2	1
Legal Services	81.1	100.0	18.9	38.5	2	0
Security and Protective Services	9.5	9.5	91.8	1.3	1	1

TABLE B-14: Vulnerability by Occupational Attribute; Manufacturing

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Manufacturing	33.2	12.3	97.2	84.9	2	2
Pathways						
Health, Safety, and Environmental Assurance	0.0	0.0	100.0	0.0	1	1
Logistics and Inventory Control	34.8	0.0	100.0	100.0	2	2
Maintenance, Installation, and Repair	44.3	27.6	97.6	68.9	2	2
Manufacturing Production Process Development	19.3	13.6	82.7	17.0	1	1
Production	35.9	11.8	98.9	98.3	2	2
Quality Assurance	0.0	0.0	100.0	100.0	2	2

TABLE B-15: Vulnerability by Occupational Attribute; Marketing

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Marketing	78.2	53.0	72.6	73.2	4	2
Pathways						
Marketing Communications	0.0	100.0	29.5	0.0	1	0
Marketing Management	67.1	100.0	0.0	0.0	2	0
Marketing Research	0.0	100.0	0.0	0.0	1	0
Merchandising	100.0	4.9	85.4	95.1	3	2
Professional Sales	81.2	55.6	76.9	77.0	4	2

TABLE B-16: Vulnerability by Occupational Attribute; Science, Technology, Engineering, and Mathematics

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Science, Technology, Engineering, and Mathematics (STEM)	15.8	35.6	33.7	6.0	1	0
Pathways						
Engineering and Technology	15.5	11.5	40.5	1.3	0	0
Science and Mathematics	16.3	79.9	21.2	14.7	1	0

TABLE B-17: Vulnerability by Occupational Attribute; Transportation, Distribution, and Logistics

	Percentage of Jobs in Cluster/Pathway				Vulnerability Score	
	High Disease Exposure	Not Critical Workforce	Low Remote Work Potential	High Automation Risk	Short Run (0-4)	Long Run (0-2)
AVERAGE (ALL CLUSTERS)	**58.3**	**30.4**	**60.5**	**48.9**	**--**	**--**
Cluster						
Transportation, Distribution, and Logistics	11.1	12.1	91.4	44.3	1	1
Pathways						
Facility and Mobile Equipment Maintenance	0.0	0.8	100.0	21.6	1	1
Health, Safety, and Environmental Management	--	--	--	--	--	--
Logistics Planning and Management Services	0.0	0.0	3.9	0.0	0	0
Sales and Service	0.0	30.0	59.3	100.0	1	1
Transportation Operations	23.5	24.1	98.8	33.5	1	1
Transportation Systems/Infrastructure Planning, Management, and Regulation	53.2	0.0	46.8	100.0	1	1
Warehousing and Distribution Center Operations	5.3	5.7	94.7	82.0	2	2

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