RESEARCH ARTICLE

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Fragmentation in the future of work: A horizon scan examining the impact of the changing nature of work on workers experiencing vulnerability

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Abstract

Introduction: The future of work is characterized by changes that could disrupt all aspects of the nature and availability of work. Our study aims to understand how the future of work could result in conditions, which contribute to vulnerability for different groups of workers.

Methods: A horizon scan was conducted to systematically identify and synthesize diverse sources of evidence, including academic and gray literature and resources shared over social media. Evidence was synthesized, and trend categories were developed through iterative discussions among the research team.

Results: Nine trend categories were uncovered, which included the digital transformation of the economy, artificial intelligence (AI)/machine learning-enhanced automation, AI-enabled human resource management systems, skill requirements for the future of work; globalization 4.0, climate change and the green economy, Gen Zs and the work environment; populism and the future of work, and external shocks to accelerate the changing nature of work. The scan highlighted that some groups of workers may be more likely to experience conditions that contribute to vulnerability, including greater exposure to job displacement or wage depression. The future of work could also create opportunities for labor market engagement.

Conclusion: The future of work represents an emerging public health concern. Exclusion from the future of work has the potential to widen existing social and health inequities. Thus, tailored supports that are resilient to changes in the nature and availability of work are required for workers facing vulnerability.

KEYWORDS

future of work, labor market exclusion, social and health inequities, social determinants of health, vulnerable workers, work arrangements, work environment

1 | BACKGROUND

The world of work is rapidly changing. An increasing amount of research has focused on understanding how changes in the future of work will impact workers and workplaces.[1-3] There are fewer studies that explore issues affecting how the future of work will impact specific labor market subgroups, especially those who could be disadvantaged by changing work arrangements and work conditions. To better understand these issues, we conducted an expansive horizon scan of evidence to identify and describe trends that characterize the future of work for vulnerable workers. By synthesizing the literature, insight into potential challenges and opportunities for certain groups of workers can be revealed as the working world changes. These findings also provide important directions for additional research that can be used to inform the design of programmatic and policy responses that will support the inclusion of vulnerable workers in the future of work.

A recent analysis found that close to two-thirds of occupational titles in 2018 had not been invented as of 1940.[4] The rise of new occupations has largely been driven by technological change. Some labor market experts posit that we are entering a Fourth Industrial Revolution that is driven by the digitization and automation of social, political, economic, and environmental domains of life that has the potential to drastically speed up the pace of change.[5] Literature on factors influencing work trends and related outcomes ("the future of work") also indicates that the advancement and adoption of different digital technologies can be coupled with sociodemographic (e.g., aging population), sociopolitical (e.g., globalization), and ecological changes (e.g., climate change).[4,6-8] Not surprisingly, the future of work is characterized by the potential for dramatic change to every industry and the considerable transformation of the nature of work (e.g., evolving work conditions, job skills and training requirements, psychosocial resources and demands, environmental conditions, and work arrangements).[9,10] Some argue that changes in the future of work are occurring at a larger scale and at a quicker pace when compared to past periods of technological adoption.[11] Importantly, the future of work is emerging from ongoing shifts within industrialized labor markets that include a transition from manufacturing to a service-based economy, increased offshoring of work, growth in nonstandard and precarious work arrangements (e.g., gig work), a decline in union representation and legislative protections for workers and widening income inequality.[12-15] Of concern, recent studies suggest that employers, policymakers, and workers report lacking the insights and tangible strategies to ensure preparation for large-scale shifts in the nature of work.[16] This knowledge gap may have significant implications for workers who have been exposed to circumstances that may contribute to vulnerability.

Our definition of vulnerability is informed by research that considers the intersection between work context and worker characteristics.[17] In particular, in our study, we use the term vulnerable workers to refer to groups of workers who are exposed to structural factors (e.g., racism, ableism, sexism) that may contribute to adverse work arrangements or work environments, including precarious work, low-wage employment, and hazardous conditions. Vulnerable workers may also face an absence of regulatory protections, union representation, career advancement opportunities, or may have high job demands and low decision latitude.[17-21] Studies show that certain groups of workers have been more likely to be exposed to circumstances that contribute to vulnerability when compared to population averages, including youth and young adults, women, racialized groups, recent immigrants, people with disabilities, members of the LGBTQ2+ community, Indigenous peoples, and those with low socioeconomic status.[17,19,22-31] Studies of past periods of technological advancement (e.g., introduction of personal computers to workplaces) or economic change (e.g., Great Recession) showed growth in social and health inequities with these groups of workers who were more likely to report barriers to high-quality employment when compared to population averages.[32,33] It is unclear how the anticipated changes in the future of work will impact levels of vulnerability in the labor market. It is also unclear whether there may be a positive effect related to the changing nature of work for vulnerable workers. A comprehensive scan of trends in the future of work is necessary to identify the changes to work arrangements or work environments that can contribute to disadvantage for different groups of workers. Moreover, our research has important implications for policy and programmatic directions that are specifically beneficial for workers who could be excluded from the future of work.

Promoting sustained employment for vulnerable workers represents a critical public health priority. A body of research demonstrates that working conditions are directly tied to the physical and mental health of workers and may contribute to health and social inequities in the working population.[34,35] Research on the social determinants of health finds that employment income is associated with access to safe housing, education, food security, social services, and medical care that provide pathways to better health.[12,18,36-38] The importance of our study of the future of work is further underscored by the United Nation's (UN) Sustainable Development Goal #8 on Decent Work. According to the UN, promoting inclusive and decent work (i.e., productive work that delivers a fair income, job security, and social protections) represents an important policy priority to foster the health and well-being of the working population.[39] Dedicated approaches are needed to ensure that vulnerable workers are protected from challenges that could emerge in the future of work and as a strategy to promote health.

Using a comprehensive horizon scan of a diverse body of literature, our study aims to understand how the future of work might contribute to levels of vulnerability. Specific objectives of this study are to (1) identify existing evidence on different trends that may span social, technological, economic, environmental, and political domains and characterize the future of work; and (2) to synthesize and describe how each trend might impact vulnerability within the labor market.

2 | METHODS

To address study objectives, we utilized a novel horizon scan methodology. Horizon scanning is a systematic information-generating activity commonly used in the field of strategic foresight

—a planning-oriented discipline related to future studies—to identify trends that have the potential to emerge over time.[40-42] The horizon scanning process is inclusive and seeks to identify and synthesize diverse sources of evidence (e.g., academic research, gray literature, and social media).[43,44] Our horizon scan was conducted between December 2019 and January 2020 and focused on synthesizing evidence within Organisation for Economic Co-operation and Development (OECD) countries that have similar socioeconomic and policy contexts. The process was subsequently updated in August 2020 to capture literature on the changes to the nature of work resulting from the coronavirus disease 2019 (COVID-19) pandemic. Our synthesis leveraged expert insight from a multidisciplinary research team with a background in industrial and organizational psychology, economics, public health, occupational health, public policy, organizational behavior and human resource management. Members of the research team also had specific expertise on vulnerable workers and literature review and evidence synthesis methodologies.

2.1 | Literature search

2.1.1 | Generation of future of work search terms

To develop the search terms for the scan, several steps were undertaken. First, members of our research team identified seminal research reports on the future of work. Seminal reports were ranked according to authorship reputation and thoroughness in the report's description of anticipated changes to the future of work.[3,6,45-47] Based on their ranking, five seminal reports were used as an initial guide to extract search terms that spanned social, technological, economic, environmental, and political domains. Search terms were then finalized with input from a library scientist (Table 1). Terms spanning social, technological, economic, environmental, and political categories were searched using a Boolean *OR* operator and combined with work outcome search terms, future- and change-related search terms, and worker vulnerability terms using a Boolean *AND* operator.[46,48] The list of search terms is presented in Supplement 1. To capture the most more recent changes in the nature of work, the search was restricted to articles published between 2015 to September 2020.

2.1.2 | Peer-reviewed and gray literature search

Six search portals were used to uncover peer-reviewed and gray literature across diverse disciplines: Applied Social Sciences Index & Abstracts, Canadian Business & Current Business Source Premier, International Bibliography of the Social Sciences, Public Affairs Information Service Index, Sociological Abstracts, and Worldwide Political Science Abstracts. Database-specific controlled vocabulary terms and keywords were included. Reference lists of included studies were also examined to identify references not found in the

literature search. Once duplicates were removed, titles and abstracts were imported into a shared spreadsheet to facilitate the screening processes.

2.1.3 | Social media search

A search of the social media site Twitter also was performed to capture ideas on the future of work and complement the findings from academic and gray literature searches.[49] Twitter is commonly used for the public communication of topics with policy relevance and provides an interactive platform that can capture insights from over 330 million users.[50,51] Using the hashtag function, search terms described in the section above were entered into Twitter's standard search interface.[52] Twitter searches occurred in January 2020 and were repeated in August 2020 to capture changes attributed to the COVID-19 pandemic. Given the large number of tweets focusing on the future of work, we restricted our search to tweets where there was at least a moderate amount of engagement (i.e., ≥five likes or retweets) and where the tweet included a link to a specific resource (e.g., gray and peer-reviewed literature or a website).

2.2 | Relevancy screen and thematic synthesis

Titles and abstracts or executive summaries of the literature uncovered from peer review and gray literature sources and the social media search were reviewed by a member of our research team to determine relevancy. Eligible English language literature that was carried forward in our synthesis documented a potential trend that would result in a change to the nature of work, focused on an OECD context, and described an explicit impact on levels of vulnerability for workers.[53] Next, members of the research team reviewed each relevant article and synthesized the salient themes using a shared spreadsheet. The synthesis of literature involved summarizing the article, its impact on the future of work, and how it could contribute to vulnerability. Where possible, the team also documented specific groups of workers who could be most affected by a change in the nature of work. Discussions between members of the research team were held to categorize articles according to common themes. Through this iterative process, trend categories were developed. All procedures were pilot-tested before being implemented widely to ensure members of the study team could screen and synthesize a large body of evidence.

3 | RESULTS

The search uncovered a large literature base on the future of work (Figure 1). However, fewer studies examined the impact of the future of work on vulnerable workers. An initial search yielded 4800 articles after removing duplicates. Following an examination of the relevancy of titles and abstracts, 3198 articles were screened out.

Members of the research team reviewed titles and abstracts of 1602 articles of which 342 articles were fully reviewed and synthesized. On the whole, articles that we identified were from peer-reviewed or gray literature sources and tended to span multiple disciplines to describe or project the impact of a dimension of the future of work on levels of vulnerability.

Our in-depth synthesis of articles resulted in the identification of nine trend categories that spanned social, technological, economic, environmental, and political domains, and cumulatively shaped work arrangements and work environments in the future. Trend categories included: (1) digital transformation of the economy; (2) artificial intelligence (AI)/machine learning (ML)-enhanced automation; (3) AI-enabled human resource management systems; (4) skill requirements for the future of work; (5) globalization 4.0; (6) climate change and the green economy; (7) Gen Zs and the work environment; (8) populism and the future of work; and (9) external shocks to accelerate the changing nature of work (the COVID-19 example). Table 2 lists the trend categories and provides a brief definition with examples. A more complete summary of each trend category and its impact on vulnerable workers is provided in the sections below. It is important to highlight that not one single group of workers was consistently represented across the literature, and, indeed, the trends we identified cut across multiple sources of worker vulnerability. As a result, in presenting our synthesis, we describe the impact of key trends broadly for different workers and elaborate on how they may shape conditions that contribute to vulnerability. Where possible, we highlight how a trend category could present challenges and opportunities for specific groups of workers.

3.1 | Trend 1: Digital transformation of the economy

A body of peer-reviewed and gray literature uncovered in our scan described the impact of advanced digital technologies on the changing nature of work, including 5G technology, Internet of Things (IoT), smart sensors, cloud computing, virtual reality (VR) and augmented reality (AR), three-dimensional (3D) printing, robotics, and blockchain technology.[1] Although very different, the studies consistently described digital technologies contributing to hyperconnectivity between people, businesses, digital devices, and data.[1,54] For example, the increasing use of IoT devices or advanced robots could mean that workers will increasingly find themselves performing job tasks that are closely integrated with machines.[55,56] Other workers, especially those employed in occupations characterized by repetitive and low-skilled job tasks may be at risk of displacement or wage depression as a result of digital technologies that facilitate automation. Data have estimated that every advanced robot introduced into the labor market per 1000 workers will reduce the employment-to-population ratio by 0.2% and contribute to a decline of wages by 0.42%.[57,58]

Some digital technologies (e.g., cloud computing, online collaboration tools) were reported as having contributed to advanced telepresence where a worker's skills and knowledge can be projected anywhere in the world to perform a range of job tasks (e.g., operating machinery or virtual brainstorming), which could be beneficial for workers requiring location flexibility or those with mobility impairments.[59-61] Studies also described the use of VR/AR to combine physical and virtual worlds that may enhance sensory experiences required for high-quality telework experiences.[62,63] In the manufacturing sector, 3D printing has contributed to the direct development of inputs required for the production of goods rather than relying on a more complex supply chain spread across geographical locations.[62,64] Advancements in digital technologies (e.g., smartphones, 5G technology) has also facilitated the exponential growth of a marketplace of gig workers that can perform on-demand physical (e.g., transport, couriering, food delivery, and cleaning), repetitive (e.g., data entry, clerical work) or cognitive job tasks (e.g., website developers, editors, and graphic designers).[11,65-67]

Despite growth opportunities, the literature we identified showed that workers who have been traditionally disadvantaged in the labor market may also be more likely to face barriers to participating in an economy undergoing a digital transformation. Studies point to groups of workers, such as those who are employed in routinized occupations, as being more likely to have job tasks or functions that can be replaced by a digital technology and are less
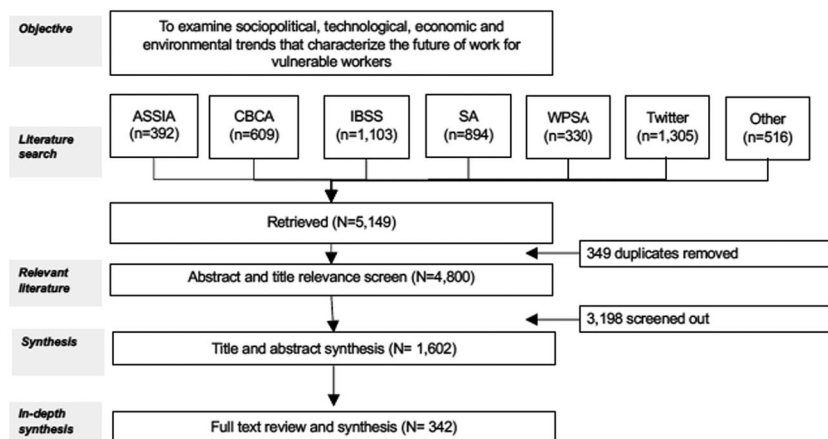
FIGURE 1 Horizon scan flow chart summarizing peer-reviewed and gray literature and social media searches, relevancy screening and thematic synthesis. ASSIA, Applied Social Sciences Index & Abstracts; CBCA, Canadian Business & Current Affairs; IBSS, International Bibliography of the Social Sciences; SA, Sociological Abstracts; WPSA, Worldwide Political Science Abstracts

TABLE 1 Summary of search terms

	Description
Population	Diverse groups who have traditionally experienced vulnerability in the labor market, including youth and young adults, women, racialized groups, immigrants, people with disabilities, members of the LGBTQ2+ community, Indigenous peoples, and individuals with low socioeconomic status
Future of work trends[a]	Social, technological, environmental, economic, and political signals of change to the nature and availability of work
Change terms[a]	Terms reflecting a future change, such as disruption, innovation, advancement, acceleration or shift
Work outcomes	Any measure of labor market activity

Note: Specific search terms are presented in Supporting Information 1.

[a]Seminal reports were used as a guide to extract an initial set of search terms, which spanned social, technological, economic, ecological and political changes, and change terms.

likely to be employed in an occupation where wages are expected to grow over time.[68-70] Exclusion from the digital economy can be exacerbated by workers who hold lower levels of education or possess less technological literacy.[69,71] At the same time, jobs that are low-paid and involve demanding manual tasks are expected to be less affected by the digitization of work (e.g., food and beverage worker, janitor, healthcare aide) and will remain in high demand in a digitized economy.[4] Another body of research suggested that the digital transformation of the economy may increase the likelihood that vulnerable workers are forced into gig work and exposed to wage instability, job insecurity or unsafe working conditions.[69,72] At the same time, gig work could also provide certain groups (e.g., youth, immigrants) with job opportunities and work experiences that are necessary to facilitate labor market entry and career advancement.[72,73] Gig work may also provide scheduling and location flexibility for groups of workers who may report activity limitations (e.g., people with disabilities) or have more caregiving responsibilities (e.g., women).[72,73]

3.2 | Trend 2: AI/ML-enhanced automation

Discourse on the future of work has tended to focus on the automation of job tasks. It is estimated that up to 60% of occupations consist of job tasks of which one-third are automatable.[74] Other more dire estimates have suggested that up to 50% of occupations are expected to be completely replaced by automated systems.[74-77] A majority of earlier studies on the automation of work have found that repetitive and low-skilled jobs are among the most likely to be automated.[75,77] At the same time, the automation of work has resulted in the development of new jobs, which may offset labor market displacement.[78]

More recent literature highlights the role of computerized systems within workplaces that draw on AI to replicate human intelligence and behaviors in performing complex and cognitive job tasks.[64] Advancements in the development of ML, neural networks, and deep learning have increased the likelihood of computerized systems performing advanced information processing and predictive jobs tasks (e.g., data analysis, communication, prediction, and

problem-solving).[67,79-84] Numerous examples of AI applications have existed in diverse sectors, including finance (e.g., algorithmic stock trading), manufacturing (e.g., intelligent robots), transportation (e.g., autonomous vehicles), and retail (e.g., chatbot customer service assistants).[64,85] In many of these cases, workers and machines may be required to jointly complete job tasks.[86] The growing use of AI and ML applications in the labor market has produced mixed outcomes. AI/ML-enhanced automation of job tasks could minimize the availability of employment opportunities but also drive innovation and create new jobs.[54,87,88] Also, a growing number of employers reported utilizing AI to assist workers and increase productivity, especially for workers in occupations that rely on information, calculation, problem-solving, and communication.[4,86]

The literature identified in our scan showed that AI/ML-enhanced automation has the potential to contribute to vulnerability for some groups of workers.[74,89] Workers in occupations that are at greater risk of having their work automated (e.g., those employed in low-skilled and repetitive jobs) could experience employment loss or be forced into lower-quality employment. Some studies sought to identify specific groups of workers who are more likely to work in occupations affected by the automation of work. For example, an analysis of labor market data from the United States found that Black Americans are at a 10% greater likelihood of working in occupations at risk of displacement from automated systems when compared to White Americans.[89] The same study found that being of younger age and holding low levels of educational attainment increased the susceptibility Black Americans faced to job displacement from automated systems.[89,90] A case study of the Australian mining sector showed that automation disproportionately affected Indigenous workers who were overrepresented in entry-level roles and underrepresented in higher skilled jobs (i.e., engineering and geological roles).[91] AI has the potential to exacerbate displacement for workers affected by automation and may contribute to wage depression for certain groups of workers.[92-94]

The growing application of ML within workplaces also has the potential to impact higher skilled jobs that require greater levels of prediction and could potentially contribute to a growing number of workers in professional jobs that are at risk of displacement.[95] The application of AI and ML within the workplace has also created a

TABLE 2 Summary of horizon scan examining future of work trend categories and their impact on vulnerable workers

Trend category	Description	Example	Change in levels of vulnerability
Digital transformation of the economy	Rapid advancement and large-scale application of diverse novel digital technologies resulting in hyperconnectivity between people, business, digital devices, and data	3D printing of production inputs in manufacturing - Virtual reality and augmented reality to enhance telework - Integration of Internet of Things devices within work environments	- Job displacement - Exclusion from growth opportunities - Forced gig work - Protection from displacement when employed in occupations with a greater requirement for soft skills[a]
AI/ML-enhanced automation	Increasing use of computerized systems within workplaces to replicate human intelligence and behaviors and to perform predictive job tasks	- Algorithmic stock trading in financial services - Self-driving vehicles in the transportation sector - Intelligent robots in manufacturing	- Job displacement - Wage depression - Protection from displacement when employed in occupations with a greater requirement for soft skills[a]
AI-enabled human resource management systems	The initial parameters of AI-enabled human resources management system have the potential to introduce or reinforce biases within workplace practices	ML applied to evaluate facial expressions and language of a job applicant to make comparisons to a workplace benchmark	- Exclusion from job opportunities - Discrimination at work
Skill requirements for the future of work	Workers across all industries are required to possess advanced technical competencies, digital literacy, and soft skills	- Importance of STEM training in all industries - Growing demand for workers with soft skills that are less likely to be automatable and are increasingly required by employers	- Job skills gaps - Barriers to upskilling and reskilling
Globalization 4.0	Advancement of digital technologies will facilitate the exchange of ideas, services, and goods within physical and virtual work environments across the globe	- Tele-migration of workers performing blue- and white-collar jobs - Growth of online marketplaces consisting of international professional freelancers	Job displacement
Climate change and the green economy	A changing climate and extreme weather events will impact employment opportunities and work conditions. New jobs designed to address climate change will also be developed	- Climate events will interrupt certain industries and occupation - Development of jobs in new sectors (e.g., biodesign, renewable energy)	- Job displacement - Productivity loss - Exclusion from job opportunities - Increased exposure to health and safety risks
Gen Z workers and the work environment	Growing numbers of Gen Z workers (born 1995–2005) could bring greater diversity to workplaces and facilitate more inclusive employer attitudes and behaviors	Gen Z workers will prioritize employment in an organization whose values align with their own	- Accessible work environments[a] - Skill development opportunities[a]
Populism and the future of work	Growth in populist values within industrialized countries can contribute to discrimination according to personal characteristics and exclusion of some groups of workers from the labor market	Growing numbers of industrialized countries are electing political leaders with populist platforms	- Exclusion from job opportunities - Discrimination at work
External shocks to accelerate the changing nature of	External shocks have the potential to accelerate trends in the future of work.	COVID-19 increased employer use of digital technologies to support work-from-home arrangements	- Job displacement - Wage depression - Increased exposure to health and safety risks

TABLE 2 (Continued)

Trend category	Description	Example	Change in levels of vulnerability
work (COVID-19 example)		• Increased employer investment in AI to improve productivity and address COVID-19-related safety concerns	• Growth in flexible work arrangements

Abbreviations: AI, artificial intelligence; COVID-19, coronavirus disease 2019; ML, Machine learning; STEM, science, technology, education, math training.

aOpportunity for vulnerable workers in the future.

demand for workers with emotional intelligence.[3] It is important to highlight that data comparing gender groups have shown that women are overrepresented in occupations (e.g., nurse, social worker, teacher) that have a greater requirement for emotional intelligence.[96,97]

3.3 | Trend 3: AI-enabled human resource management systems

Increasingly, AI is being integrated into human resource management systems, including job applicant tracking, job matching selection software, and performance management systems that intend on making fairer management decisions.[54,98-100] In an employee selection context, for example, ML technologies have been applied to evaluate facial expressions and the language used by job candidates who are filmed and compared to workplace benchmarks (e.g., high performers within an organization) to examine tone and inflection of voice, emotion, and facial reactions.[101] Evidence from our scan indicated that AI-enabled human resource management systems may collect personal information without explicit consent from the worker (e.g., disability status, lifestyle, age) and has the potential to contribute to discrimination or the exclusion of certain groups according to their individual traits that are not relevant to the performance of a job.[102] The potential for discrimination can stem from decisions made during the development of algorithms used to inform the initial parameters of an AI-enabled human resource management system.[99,103-105] For instance, socioeconomic status, culture, and experience of software engineers can implicitly bias the development of human resource management systems and inadvertently reinforce gender, racial, or disability biases.[71,106,107] What is more, unconscious biases have the potential to be reinforced through the application and testing of these systems in nondiverse samples.

Examples, where AI-enhanced human resource management systems can adversely affect vulnerable workers include the application of predictive job interview tools, which analyze facial or behavioral cues. There is the potential to discriminate against candidates based on personal characteristics (e.g., disability, health, race, or age) who may look or behave differently from a benchmark.[108,109] As another example, some companies have used gamified assessments (e.g., video game-based pre-employment assessments) that could contribute to discriminatory hiring practices

for older adults who are less likely to use these technologies in their daily lives when compared to younger job candidates.[108] What is more, gamified assessments could also be more complex to accommodate for workers with disabilities.[109] Our review also found that AI-facilitated productivity systems that actively monitor workers to optimize productivity and outputs could disadvantage persons with disabilities who have physical or cognitive impairment and could perform job tasks in ways that differ from a predefined standard or may require job accommodations or adaptations to perform work responsibilities.[83,108]

3.4 | Trend 4: Skill requirements for the future of work

Related to the digital transformation of the economy and the increasing application of AI and ML within workplaces, our review highlighted growing research that the future of work will be marked by the creation of new jobs requiring specialized skills. A survey showed that by 2022, at least half of employers report that their workers will be required to undertake significant reskilling or upskilling to adapt to changing technological and social demands within their workplaces.[1] To meet emerging skill requirements, the literature indicated that workers across all industries will need to possess advanced technical competencies and digital literacy (i.e., ability to find, evaluate and convey information via digital mediums).[110,111] Additionally, studies highlighted the importance of workers possessing a range of soft skills (e.g., creativity, critical thinking, collaboration skills, and empathy) that are less likely to be automated and would enable human workers to complement digital technologies and AI/ML applications within workplaces.[18,45,88,112-117] At the same time, research conducted among employers suggests that workers may not possess the technological or soft skills required in the future of work.[118,119] A survey of 300 business executives in the United States found that 87% of the workforce may be incorrectly anticipating job skill requirements.[120] Projections of Canada's labor force posit that by 2031 the country will experience a labor shortage of two million workers.[121] Shortages are expected to be highest in professions requiring training in science, technology, engineering, and/or mathematics (STEM).[121]

When compared to population averages, groups that have traditionally faced conditions that contribute to vulnerability in the

workforce (i.e., women, Indigenous peoples, people with low socio-economic status, and people living with disabilities) may also face barriers to developing the job skills that meet employer needs and may face obstacles to upskilling and reskilling opportunities, which may increase the skills divide.[7,122] Vulnerable workers may also be more likely to experience barriers to accessing digital skilling programs that are needed to obtain necessary technological competencies.[68,69,71,71,111,122-126] As an example, a Canadian population-level study found that among those aged 25–54 years with a STEM degree, less than one percent identified as a member of an Indigenous community.[127] Evidence uncovered in our scan indicated that some groups (e.g., women) may be more likely to work in occupations that have greater soft skill requirements that are reported as being valued by employers in the future.[69,128] Research also suggested that skills and training gaps may result in employers being more likely to hire from a broader talent pool.[129,130] Accordingly, the future of work could be characterized by emerging opportunities for those who may have been traditionally excluded from the workforce.[129,130]

3.5 | Trend 5: Globalization 4.0

In Globalization 4.0, the rapid advancement of technologies in the future of work is expected to further catalyze the global exchange of ideas, services, and goods in both physical and virtual spaces across the globe as well as increase the interaction and integration of people, companies, and governments.[131-134] In globalization 4.0 it is anticipated that companies and workers across different industries may operate inside of the local jurisdiction in which goods and services are delivered.[135] As an example, evidence uncovered in our synthesis described an increase in tele-migration where white-collar jobs can be done remotely by workers who are geographically distant and may be hired at a lower wage.[11] Advancements in digital technology in the future of work are also expected to increase the number of online marketplaces where freelancers can bid for work and take on employment contracts in any country.[11] Within a changing global economic structure, workers who have been traditionally disadvantaged within industrialized labor markets (e.g., those working in low-skilled jobs or in occupations with fewer educational requirements) could be at a greater risk of displacement by tele-migrants who could command lower wages, and where organizations who outsource work may be exempt from paying local income taxes or making contributions to social security and could bypass existing labor standards.[68,136,137] Some evidence posited that the continued digital transformation of labor markets could result in workers in high-skilled occupations and where job tasks are more complex to be at a growing risk of being displaced by tele-migrants. Additionally, in globalization 4.0, unsafe and insecure virtual working environments could emerge for workers who provide remote knowledge, expertise, or services and have less control over work conditions or their compensation.[135]

3.6 | Trend 6: Climate change and the green economy

Climate change (i.e., impact of human activity on Earth's ecosystem and weather patterns) and associated interventions in the green economy can impact work conditions and the availability of jobs in the future.[138-141] A synthesis of the literature in our scan highlighted that climate change and related extreme weather events (e.g., wildfires, droughts) is anticipated to contribute to the forced migration of workers, damage to workplaces, lost productivity, and impact worker health and safety (i.e., increasing occupational infectious disease transmission, air pollution, heat-related illnesses).[141-153] Those working in specific sectors (e.g., industrial services, agriculture, travel, and tourism) or geographic regions are more likely to work outdoors and are susceptible to the effects of climate change and extreme weather events.[142,143] For example, research from the United States indicated that by 2100, 6% of labor hours could be lost to heat exposure in southern states (e.g., Texas or Florida).

Alternatively, our horizon scan found that business and policy responses to curb the impact of climate change has resulted in the growth of a green economy that includes the development of new job opportunities in diverse sectors, including renewable energy, bioengineering, and biodesign.[142,143,154-162] While a shift to a green economy could mean that certain industries (e.g., oil and gas) are disrupted, some researchers project that by 2030, with policy supports, up to 24 million new jobs could be created globally and result in employment opportunities for diverse groups.[163]

Research indicated that the adverse impact of climate change on work may be disproportionately experienced by groups of workers who have traditionally experienced vulnerability in the labor market.[144,152] In particular, our horizon scan found that vulnerable workers maybe be more likely to be employed in occupations that are prone to job displacement as a result of climate change and may also have less access to social protections that support employment interruptions resulting from an extreme weather event.[144] Certain groups of workers may be most affected by climate change, including those from racialized or Indigenous communities, youth and young adults, older adults, and those with low socioeconomic status.[144,152] One study found that Indigenous persons may be especially affected by climate change because of their disproportionate reliance on natural resources for financial, cultural, and physical well-being when compared to other members of the working population.[144,164] Studies also suggested that workers exposed to precarious work environments (e.g., seasonal or casual workers) or those employed in certain industries (e.g., farming, construction) are more susceptible to workplace health and safety hazards and interruptions to employment resulting from climate change.[163] In addition, attributed to discrimination faced in the labor market and greater barriers to upskilling and reskilling, some groups of workers (e.g., women and Indigenous persons) could be at risk of exclusion from new jobs that emerge in the green economy.[165-167]

3.7 | Trend 7: Gen Z workers and the work environment

As Baby Boomers transition into retirement, the labor market will consist of a growing proportion of "Gen Z" workers (those born 1995–2005). Currently, over one-quarter of the labor market is composed of Gen Z workers.[168-170] As the number of Gen Z workers grows, it is anticipated that they could bring greater diversity to workplaces and facilitate more inclusive and supportive employer attitudes and behaviors.[80,171,172] The positive impact of Gen Z workers on workplaces can stem from several factors. First, Gen Zs report higher educational attainment, on average, than previous generations and are characterized as digital natives—the first generation to be born into an era where advanced digital technologies are commonplace.[168,173,174] Second, Gen Zs are also the most racially diverse generation in the workforce.[175] An analysis of US census data showed that Gen Zs are more likely to belong to a racial or ethnic minority group (48%) when compared to Millennials (39%) or Baby Boomers (18%).[173] Third, the career trajectory of Gen Zs is more likely to have been shaped by the Great Recession and exposure to income inequality when compared to previous generations.[170] Accordingly, studies suggested that Gen Zs are more likely to report valuing employment that provides a higher salary, greater job stability, and access to health benefits compared to previous generations.[168-170] For instance, a recent survey of over 1531 Gen Zs found that over three quarters (77%) reported prioritizing employment in an organization whose values align with their own.[168,170]

The growing proportion of Gen Z workers in the labor market could improve working conditions for groups who have been traditionally disadvantaged in the labor market. The literature highlighted that Gen Zs aspire toward being employed in workplaces that value inclusiveness, diversity, and social responsibility and where work environments are accessible to vulnerable groups.[176-178] Growing numbers of Gen Zs within the labor market could also motivate employers to implement organizational policies that support work–life balance, access to work-from-home arrangements, and environmental sustainability practices that could be beneficial to all workers, especially those that experience vulnerability.[179-184] Also, some research suggested that Gen Zs may also be more likely to encourage their employers to provide on-the-job skills development and training opportunities so that they may develop competencies that match the speed of innovation and to address the skills divide.[80,170,185]

3.8 | Trend 8: Populism and the future of work

Hypothesized as stemming from both technological advancement and globalization, the future of work could also be shaped by changing sociopolitical sentiment. Literature in the fields of political science, economics, and sociology uncovered in our scan described the impact of populism on the work environment.[186,187] There is no universal definition of populism. Drawing from the evidence we uncovered, populism can refer to a diverse set of sociopolitical movements that include an anti-establishment orientation, broad anti-elite policies, or the opposition to liberal economics and globalization.[188] Populist sentiments can be held by those across the political spectrum. At the time of this scan, political parties with populist views had grown in several industrialized countries (e.g., the United States, the United Kingdom, France, and the Netherlands).[189-192] The growth in populist values has been attributed to at least two expected future of work trends that have been previously described in this paper— the digital transformation of the economy and globalization 4.0.[191] Although changes in globalization have contributed to economic benefits for employers and governments,[191] it has also partially contributed to an increased number of jobs being outsourced, offshored, or filled by tele-migrants.[186-188] Relatedly, advancements in digital technologies and their application within workplaces have meant that an increasing number of jobs have been displaced.[94] Both trends have the potential to contribute to conditions that foster populism, including a decrease in employment opportunities, growing income inequality, and increased perceptions of unfairness, anxiety, and frustration held by a large proportion of the population.[191,193]

The growth in populist views has the potential to contribute to discrimination or labor market exclusion for workers according to their personal characteristics. As highlighted in recent examples within industrialized contexts where populist views have grown, politicians may build a base of supporters by constructing an in-group and tapping into the grievances of that in-group (e.g., lack of job opportunities, income inequality). The same politician may blame out-groups, often among the most vulnerable segments of the labor market (e.g., racialized minorities, immigrants) for economic hardships faced by the same in-group.[191,194,195] Policy responses may result from populist views in ways that may contribute to systems of exclusion from higher quality employment opportunities (e.g., full-time and secure employment) for vulnerable workers.[187,192,196,197] Within the literature on the future of work, it has been suggested that growing job losses and automation of employment resulting from advancements in digital technologies and AI applications may increase support for populist political positions.[79,94] For instance, a recent survey of 1995 Canadian workers examined how exposure to automation and AI could relate to policy preferences. Participants in the study who were more likely to fear job loss as a result of automation or AI were significantly more likely to hold populist views.[94] Given the expected digitization of the future of work highlighted in our scan, populism could continue to limit employment opportunities for some already vulnerable groups.

3.9 | Trend 9: External shocks that accelerate the changing nature of work (the COVID-19 example)

External shocks (e.g., economic recessions or depressions, natural disasters, or pandemics) have the potential to increase the level of change to the nature of work.[198,199] The impact of the spread of COVID-19 on the availability of jobs and working conditions is a prime example of an external shock that has accelerated trends in the future of work. At the

time of this study, the COVID-19 pandemic had fast-tracked numerous work-related trends highlighted in this horizon scan, including companies increasing their investment toward diverse digital technologies to sustain productivity while also addressing potential workforce safety concerns (e.g., 3D printing, cloud computing infrastructure, robotics, virtual tele-conference software, and AI).[200-203] An example, is the growth of work-from-home arrangements. In 2018, labor market estimates suggested that less than one-third of the US workforce reported having previously worked from home and most of those were in higher paying and higher skilled jobs.[204] Immediately following the start of the pandemic, several surveys found that up to two-thirds of US workers had been able to access work-from-home arrangements.[61,163,205,206] Studies indicated that the shift to work-from-home arrangements can have advantages (e.g., flexibility, an opportunity to self-accommodate tasks) and disadvantages (e.g., isolation) for workers.[207-209]

Of significance, the economic impact of the COVID-19 pandemic has had a disproportionately negative impact on workers who have traditionally experienced vulnerability (e.g., certain racialized communities, low-wage workers, and immigrants).[210-216] For instance, data from Canada highlighted that in some regions over two-thirds of COVID-19 infections have been experienced by racialized groups.[212] Data from a range of industrialized contexts indicated that some groups of workers were more likely to be employed in jobs with greater risk of exposure to COVID-19 and where health and safety protections and work-from-home arrangements were less likely to be provided.[217-224] As an example, a survey of 8572 workers in the United States found that the top quintile of earners was more likely to access a work-from-home arrangement (71%) compared to the bottom quintile of earners (41%).[214] Similarly, certain groups of workers may be more likely to be employed in industries or occupations, which are at a higher risk of displacement as a result of the COVID-19 pandemic.[215,221,225-232] For instance, US labor force data indicated that women were at least 1.8 times more likely to experience job displacement as a result of the COVID-19 pandemic compared to men.[221,233] Also, in a survey of 4917 US adults, Black (44%), and Hispanic (61%) respondents were more likely to report job or wage loss compared to their White counterparts (38%).[233,234] The increasing use of digital technologies within workplaces during the COVID-19 pandemic coupled with barriers to upskilling opportunities for vulnerable workers could widen digital skills gaps and increase the likelihood of job displacement.[61] Highlighting its interrelationship with sociopolitical trends, some studies also indicated that the economic shocks of the COVID-19 pandemic have increased the populist sentiment in groups that have the power to hinder future employment opportunities for certain groups of workers.[201,215,235]

4 | DISCUSSION

Conditions within industrial labor markets are quickly changing and the result could be work arrangements and work environments that are fragmented and where pathways to health are disrupted. While growing research has described how the labor market's could change in the future of work, our study is one of the first to identify and synthesize available evidence that is tied to factors that may impact vulnerability. We uncovered nine specific future work trends that can create unique challenges and opportunities for vulnerable workers. Our study provides a foundation for subsequent scholarship on social and health inequities that could emerge in the future of work. Findings also offer a roadmap for the design of policy and programmatic priorities to ensure that the changing world of work is accessible to workers who have traditionally been marginalized.

Taking a novel horizon scan approach, we synthesized a wide range of existing literature on the future of work. Nine trend categories were identified that spanned social, technological, economic, environmental, and political domains and can change work arrangements, work environments, and broader labor market circumstances. The nine trend categories we identified could have benefits for some groups of workers but could also be harmful to others, suggesting that the future of work could be marked by disparity. Of particular concern, some groups of workers may enter the future of work at a position of disadvantage and could lack resources (e.g., barriers to educational attainment or upskilling opportunities) or be exposed to adverse working conditions (e.g., employment in occupations most susceptible to disruption) that impact their ability to navigate the changes to the working world.[236] The potential disadvantages faced by vulnerable workers could result in barriers to accessing resources (e.g., income, health benefits, social support) and may reinforce or even widen existing health and social inequities. Indeed, the future of work represents a critical public health concern. Strategies that address fragmentation in the future of work at the worker, workplace, and regulatory levels provide an important mechanism to promote sustained labor market engagement and health of the working population.

An appraisal of evidence in our horizon scan highlights important research directions on the future of work. In particular, the operationalization and measurement of vulnerability in studies of the future of work remain limited, with minimal research examining the interface between working conditions and worker characteristics (e.g., age, gender, race, disability status). There is also a paucity of research that has examined how changing conditions within the working world affect health inequities. Study findings underscore the need for additional research to define and measure vulnerability in ways that are relevant to research on the future of work. There is also a need to further examine how structural conditions (e.g., power differences, racism, ableism, sexism) may emerge or be reinforced as the working world changes and can contribute to challenges for different groups of workers.

Technological innovation is a defining feature of the future of work. The advancement and application of diverse digital technologies coupled with the integration of AI/ML into all aspects of working life can result in greater efficiency and productivity for employers.[54] Technological innovation can also contribute to job displacement and wage depression for vulnerable workers. Of concern, some workers have the potential to experience a job skills trap where they may be less likely to possess technical competencies, work in occupations with fewer advancement opportunities, and be exposed to

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system-level barriers to accessing reskilling programs. For instance, studies conducted in the late 1980s and the early 1990s show that the application of personal computers contributed to displacement for those employed in entry-level or mid-level jobs (e.g., data entry clerks) that were more likely to be occupied by vulnerable groups and contributed to income polarization.[32,133,237] Compared to past examples, current technological advancements are occurring at a faster pace and are disrupting a greater number of industries and occupations.[7,11] Our scan highlights the importance of additional research to examine the impact of technological innovation on the employment conditions to which vulnerable workers are exposed. In particular, in-depth studies are needed to examine how the application of diverse digital technologies or AI/ML applications within the workplace may impact different groups of workers. Our study adds to a growing discourse on the importance of specialized upskilling and reskilling initiatives to ensure that the workforce is prepared for the digitization of work.[238] It may be that existing systems may contribute to the exclusion of some workers from the educational opportunities required for the future of work. Skills-based training initiatives are required to be expanded and tailored toward specific groups of workers to ensure equitable support for workforce preparation and enable sustained employment involvement.[74,239]

Interestingly, our study highlighted an intersection between technological innovation and social and political changes that can impact the involvement of vulnerable groups in the future of work. Our review uncovered literature showing that the digital transformation of the economy and AI/ML-enhanced automation has contributed to changes in globalization and also influenced political sentiments.[11,94] These sociopolitical shifts have the potential to exacerbate challenges faced by vulnerable workers. Our horizon scan can be contextualized using previous research, which has shown that periods of technological advancement and rapid globalization have contributed to wage depression and increases in precarious work that were more likely to be experienced by vulnerable groups of workers.[240-243] It is expected that the rapid degree of technological change we identified will further catalyze the sociopolitical trends and increase their impact on vulnerable workers. Additional research within multidisciplinary teams is required to unpack how the relationships between technological change, sociopolitical shifts, and specific work experiences are experienced by different groups of workers.

Importantly, our scan highlighted opportunities for traditionally disadvantaged workers in the future of work. Our review also found that workers in certain occupations that are reliant on soft skills may be less likely to be disrupted by digital technologies or automated systems.[244] The digital transformation of the economy, AI/ML applications that increase productivity, growing access to work-from-home arrangements, and an emerging green economy are examples of trends that will create new jobs that will demand workers with specialized technical and soft job skills, and may serve as entry points for workers into the labor market. Additionally, a generational shift in the workforce (i.e., decreasing Baby Boomers and growing Gen Zs

in the labor market) has the potential to further foster inclusive employment practices. It is unclear to what extent vulnerable workers will have access to the opportunities that can emerge in the future of work. Moreover, it is unknown whether the inclusive employment values brought about by a generational shift in the labor force will be sufficient to mitigate the impact of deteriorating working conditions that can create barriers to participation in the future of work. Research is required to elaborate on our findings to examine the extent to which vulnerable workers may access opportunities in the future of work to address anticipated labor market shortages.[74,245] Furthermore, identifying opportunities in the future of work represents an important direction to meet the UN's Sustainable Development Goal #8 on Decent Work. Policy responses that are tailored to vulnerable workers to promote access to high-quality employment opportunities and barrier-free working conditions can be critical in ensuring decent work and productivity in the future.

The future of work is a dynamic research topic that is constantly changing and can be drastically altered by external shocks. Our horizon scan was updated to account for changes in working conditions caused by the COVID-19 pandemic. Results showed that the COVID-19 pandemic disproportionately affected vulnerable workers who were more likely to report elevated health and safety risks and job disruptions. Findings from our scan also suggested that the COVID-19 pandemic may have contributed to an acceleration of the trend categories that we identified and may exacerbate challenges faced by vulnerable groups in the future of work. Our findings can be viewed within the context of previous research that has highlighted the impact of external shocks on the labor market. For instance, studies of the Great Recession show that the impact of the economic downturn was more likely to contribute to loss of employment, income inequality, and erosion of standard work opportunities for certain groups of workers (e.g., youth, low-skilled workers).[246] Numerous studies also show that the Great Recession contributed to detrimental physical and mental health consequences that were disproportionately experienced by vulnerable workers, especially in contexts with weak social and health protections.[247-250] Drawing from the experiences of the COVID-19 pandemic, an external shock (e.g., climate events, periods of recession) has the potential to unexpectedly change the nature of work and impact pathways to health.[199] Continued scanning of new trends is required to capture the dynamics of the changing nature of work and identify the work- and health-related impacts of these shocks. Furthermore, within the context of a changing labor market, research is also required to continue to understand social policies and labor protections that can be implemented to ensure that vulnerable workers and workplaces are resilient to unpredictable shocks.

There are strengths and limitations of our study that should be acknowledged. Our horizon scan methodology enabled the research team to synthesize diverse sources of literature on the future of work to identify salient tend categories. Our scan took an inclusive approach to identify peer-reviewed, gray literature and social media sources with implications for vulnerable workers. At the same time,

we acknowledge that there may be additional trends that can drive change in the nature of work that may not have been detected. Additionally, our horizon scan aimed to uncover research on how levels of vulnerability may be affected in the future of work and specific groups of workers who may be more likely to experience disadvantage. No one particular group of workers was consistently represented in the literature. As a result, we took a broader perspective toward vulnerability and examined how the future of work could impact work arrangements, work conditions, and broader structural factors that may drive disadvantage. It is important to acknowledge the heterogeneity of experiences of different workers. Studies are needed to capture the diverse challenges and opportunities for specific groups who have been exposed to vulnerable work conditions (e.g., youth and young adults, women, racialized groups, immigrants, people with disabilities, members of the LGBTQ2+ community, Indigenous persons, and those with low socioeconomic status). Interestingly, several studies identified in our scan found that workers belonging to more than one vulnerable group may face labor market conditions that exacerbate susceptibility to displacement and disadvantage in the future of work.[89,251] Research applying an intersectional lens could elaborate on the overlapping identities and macrolevel structures that may contribute to inequalities. Lastly, our horizon scan did not identify specific policies or programs that could address the vulnerability in the future of work. Generating applied solutions represents an important next step in the research.

5 | CONCLUSION

The future of work is an emerging public health concern. Our scan and synthesis of existing literature identified nine trend categories that pose challenges and opportunities for the sustained employment of vulnerable workers in the future. Exclusion from the future of work has the potential to widen existing social and health inequities already facing vulnerable worker groups. Our study provides an important first step in understanding the work and health implications of the future of work and directs attention toward research and practice on vulnerable workers within the context of the changing nature of work.

CONFLICTS OF INTEREST

Cameron D. Norman is the principal and president of Cense Ltd. Cameron D. Norman has no financial or personal conflicts of interest related to the study. No other authors have competing interests related to this study to report.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.