Fragmentation in the Future of Work: A Horizon Scan Examining the Impact of the Changing Nature of Work on Vulnerable Workers

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Abstract

Background. The future of work is characterized by social, technological, economic, environmental and political changes that are expected to disrupt all aspects of the working world. Our study aims to understand how the future of work impacts vulnerable workers.

Methods. We conducted a horizon scan to systematically identify and synthesize diverse sources of evidence including academic research, gray literature and social media. Search terms were generated by members of the multidisciplinary research team, and combined with work outcome, future- and change-related and vulnerable worker search terms. Six search portals were used to uncover peer reviewed and gray literature across diverse disciplines. Search terms were also entered into Twitter's standard search interface to identify social media resources. Literature was screened for eligibility (i.e., English language, documented a change in the nature of work, industrialized context and description of impact to vulnerable workers). Each relevant article was synthesized, and trend categories were developed by through iterative discussions among the research team.

Results. An initial search yielded 4,800 articles after removing duplicates. Following a title and abstract relevancy screen, 3,195 articles were excluded. A total of 342 articles were fully reviewed. A synthesis of articles found nine trend categories which included digital transformation of the economy, artificial intelligence (AI)/machine learning (ML)-enhanced automation, AI-enabled human resource management systems, skill requirements for the future of work; globalization 2.0, 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 COVID-19 example). Some workers may be more likely to experience vulnerability in the future of work including greater exposure to job displacement or wage depression. However, some potentially positive future of work trends also existed and could be beneficial for the labor market engagement of certain groups.

Discussion. The changing nature of work can be fragmented for different groups of workers. Our research offers an important step towards understanding and supporting the involvement of vulnerable workers in the future of work.

Background

The nature of work is rapidly changing and an increasing amount of research within industrialized countries has focused towards understanding how changes in the future 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 scan of peer-reviewed and gray research 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 nature of work 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.

Labor market experts posit that we are entering a Fourth Industrial Revolution that is driven by large-scale and rapid digitization and automation of social, political, economic and environmental domains of life [4]. 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) [5–7]. 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., work conditions, evolving job skills and training requirements, psychosocial resources and demands, environmental conditions and work arrangements) [8, 9]. Changes in the future of work will occur on top of ongoing shifts within industrialized labor markets that include a transition from manufacturing to a service-based economy, increased offshoring of work and growth in non-standard work arrangements (e.g., gig work) [10, 11]. Of concern, recent studies suggest that employers and policymakers report lacking the insights and tangible strategies to ensure workers and workplace are prepared for large-scale shifts in the nature of work [12]. This knowledge gap maybe especially significant for vulnerable workers who have traditionally faced barriers to engagement in the labor market that could be exacerbated by changes in the future of work.

Our definition of vulnerability is informed by research that considers the intersection between the characteristics of the work environment and the worker [13]. In particular, vulnerable workers refer to groups of workers who may face an adverse work arrangement or work environment such as those exposed to precarious work, low wage employment, hazardous conditions, and may face an absence of regulatory protections, career advancement opportunities or may have high job demands and low decision latitude [13–17]. Studies show that certain groups of workers have been more likely to be exposed to adverse work environments 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 [13, 15, 18–27]. 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 [28, 29]. It is unclear how the anticipated changes in future of work will impact levels of vulnerability in the labor market. It is also unclear whether there may be a positive effect of change on vulnerable workers. A comprehensive scan of trends in the future of work is necessary to identify the changes to work arrangement or work environments that can contribute to disadvantages 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 physical and mental health of workers and may contribute to health and social inequalities in the working population [30, 31]. Research on the social determinants of health finds that employment income is positively associated with access to safe housing, education, food security, social services and medical care that provide pathways to better health [10, 14, 32–34]. Also, the importance of our study 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 approach to foster health and well-being of the working population [35]. Within the context of the future of work, dedicated strategies are needed to ensure that vulnerable workers are protected from challenges that could emerge.

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) To 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.

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 to identify trends that have the potential to emerge over time [36–38]. Similar to a scoping review, 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) [39, 40]. Our horizon scan was conducted between December 2019-January 2020. The process was subsequently updated in August 2020 to capture literature on the changes to the nature of work resulting from the 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, and 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.

Literature Search

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 five seminal research reports that were published by reputable organizations and described anticipated changes to the future of work [3, 5, 41–43]. The seminal reports were used as a guide to extract an initial set of search terms which spanned social, technological, economic, environmental and political domains. Search terms were then finalized with input from a library scientist.

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 vulnerable worker terms using a Boolean *AND* operator [42, 44]. The list of search terms are 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.

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 (ASSIA), Canadian Business & Current Business Source Premier, International Bibliography of the Social Sciences (IBSS), PAIS 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.

Social media search

A search of the social media site Twitter also was performed to capture ideas on changes in the nature of work and complement the findings from academic and gray literature searches [45]. 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 [46, 47]. Using the hashtag function, search terms described in the section above were entered into Twitter's standard search interface [48]. Twitter searches occurred in January 2020. The search was 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., $\geq$ five likes or re-tweets) and where the tweet included a link to a specific resource (e.g., gray and peer reviewed literature or website).

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 industrialized context and described an explicit impact on levels of vulnerable for workers [49]. Next, a member of the research team reviewed each relevant article and synthesized the salient themes. In particular, 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.

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Results

The search uncovered a large literature base on the future of work (see Fig. 1). However, fewer studies examined the impact of the future of work on vulnerable workers. An initial search yielded 4,800 articles after removing duplicates. Following an examination of the relevancy of titles and abstracts, 3,198 articles were screened out. Members of the research team reviewed titles and abstracts of 1,602 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.

[Figure 1 about here]

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 environment in the future. Trend categories included: 1) digital transformation of the economy; 2) artificial intelligence (AI)/machine learning-enhanced automation; 3) AI-enabled human resource management systems; 4) skill requirements for the future of work; 5) globalization 2.0; 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 (COVID-19 example). Table 1 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 vulnerable workers. Where possible, we highlight how a trend category could present challenges and opportunities for specific groups of workers.

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, LGBTQ2+, Indigenous peoples, individuals with low socioeconomic status
Future of work trends[†]	Social, technological, environmental, economic and political signals of change to the nature of work
Change terms[†]	Terms reflecting a future change such as disruption, innovation, advancement, acceleration, shift
Work outcomes	Any measure of labor market activity
Note: Specific search terms are presented in Supplement 1; [†] = 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	

Table 1

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 large numbers of novel digital technologies resulting in hyperconnectivity between people, business, digital devices and data	<ul style="list-style-type: none"> • 3D printing of production inputs in manufacturing • Virtual reality and augmented reality to enhance telework 	<ul style="list-style-type: none"> • Job displacement • Exclusion from growth opportunities • Forced gig work • Protection when employed in occupations with a greater requirement for soft skills*
AI/ML-enhanced automation	Increasing use of computerized systems within workplaces to replicate human intelligence and behaviours and to perform predictive job tasks	<ul style="list-style-type: none"> • Algorithmic stock trading in financial services • Self-driving vehicles in the transportation sector • Intelligent robots in manufacturing 	<ul style="list-style-type: none"> • Job displacement • Wage depression • Protection when employed in occupations with a greater requirement for soft skills*
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 workplaces	<ul style="list-style-type: none"> • ML applied to evaluate facial expressions and language of a job applicant and make comparison to a workplace benchmark 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Importance of STEM training in all industries • Soft skills (e.g., emotional intelligence) are expected to be less automatable and are increasingly required by employers 	<ul style="list-style-type: none"> • Job skills gaps • Barriers to upskilling and reskilling

Trend category	Description	Example	Change in levels of vulnerability
Globalization 2.0	Advancement of technologies will facilitate exchange of ideas, services and goods from physical to virtual environments across the globe	<ul style="list-style-type: none"> • Tele-migration of workers performing blue- and white-collar jobs • Growth of online marketplaces consisting of international freelancers 	<ul style="list-style-type: none"> • 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 the effect climate change will also be developed	<ul style="list-style-type: none"> • Climate events will interrupt certain industries and occupation • Development of jobs in new sectors (e.g., biodesign, renewable energy) 	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Gen Z workers will prioritize employment in an organization whose values align with their own 	<ul style="list-style-type: none"> • Accessible work environments* • Skill development opportunities*
Populism and the future of work	Growth in populist values within industrialized can contribute to discrimination according to personal characteristics and exclusion of some groups of workers from the labor market	<ul style="list-style-type: none"> • Growing numbers of industrialized countries are electing political leaders with populist platforms 	<ul style="list-style-type: none"> • Exclusion from job opportunities • Discrimination at work
External shocks to accelerate the changing nature of work (COVID-19 example)	External shocks have the potential to accelerate trends in the future of work.	<ul style="list-style-type: none"> • COVID-19 increased employer use of digital technologies to support work-from-home arrangements • Companies employer investment in AI to improve productivity and COVID-19-related safety concerns 	<ul style="list-style-type: none"> • Job displacement • Wage depression • Increased exposure to health and safety risks

Trend category	Description	Example	Change in levels of vulnerability
Notes: AI = artificial intelligence; ML = Machine learning; STEM = Science, technology, education, math training; * = opportunity for vulnerable workers in the future.			

[Table 1 about here]

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 like 5G technology, Internet of Things (IoT), smart sensors, cloud computing, virtual reality (VR) and augmented reality (AR), 3D printing, robotics and blockchain technology [1]. Although very different, the studies noted that digital technologies contribute to hyperconnectivity between people, business, digital devices, and data [1, 50]. For example, the increasing use IoT devices or advanced robots could mean that workers will increasingly find themselves performing job tasks that are closely integrated with machines [51, 52]. 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. Some data indicate that every advanced robot introduced into the labor market per 1,000 workers will reduce the employment-to-population ratio by 0.2% and contribute to a decline of wages by 0.42% [53, 54].

Some digital technologies (e.g., cloud computing and 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 of machinery or virtual brainstorming sessions) which could be beneficial for workers requiring location flexibility or those with mobility impairments [55–57]. 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 [58, 59]. In the manufacturing sector, 3D printing has contributed to direct development of inputs required for the production of goods rather than relying on a more complex supply chain spread across geographical locations [58, 60]. 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, couriership, food delivery and cleaning), repetitive (e.g., data entry, clerical work) or cognitive job tasks (e.g., website developers, editors, graphic designers) [61–64].

Literature we identified showed workers who have been traditionally disadvantaged in the labor market may also be more likely to be excluded from an economy undergoing a digital transformation. Studies point to groups of workers, such as those who are employed in lower skilled or routinized occupations, as being more likely to have job tasks or functions replaced by a digital technology and less likely to be employed in an occupation where wages are expected to grow over time [65–67]. Exclusion from the digital economy can be exacerbated by workers who hold lower levels of education or possess less

technological literacy [66, 68]. Another body of research suggests that the digital transformation of the economy may increase the likelihood that vulnerable workers are more likely to be forced into gig work and exposed to wage instability, job insecurity or unsafe working conditions [66, 69]. At the same time, some literature in our review showed that 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 [69, 70]. 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) [69, 70].

Trend 2: artificial intelligence (AI)/ machine learning (ML)-enhanced automation

Discourse on the future of work has tended focus on the automation of job tasks. It is estimated that up to 60% of occupations consist of job tasks where one third of the tasks are automatable [71]. Other more dire estimates suggest that up to 50% of occupations are expected to be completely replaced by automated systems [71–74]. 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 [72, 74]. More recent literature highlighted the role of computerized systems within workplaces to drawing on AI to replicate human intelligence and behaviours in performing complex and cognitive job tasks [60]. Furthermore, advancements in the development of ML, neural networks, and deep learning has increased the likelihood of computerized systems performing advanced information processing and predictive jobs tasks (e.g., data analysis, communication, prediction and problem solving) [63, 75–80]. Studies indicated that outcomes of the growing use of AI and ML applications in the labor market have been mixed. AI/ML-enhanced automation of job tasks could minimize the availability of employment opportunities but also drive innovation and create new jobs [50, 81, 82]. Also, a growing number of employers report utilizing AI to assist workers and increase productivity [83]. Literature uncovered in our scan noted numerous examples of AI applications 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) [60, 84]. In many of these cases, workers and machines may be required to jointly complete job tasks [83].

Of concern is that literature consistently highlighted that AI/ML-enhanced automation has the potential to adversely to increase vulnerability for certain groups of worker [71, 85]. Labor market studies in our scan found that workers employed in occupations that are at risk of automation of work (e.g., those employed in low skilled and repetitive jobs) and, as a result, may experience job displacement and wage depression from the growing application of AI and ML within workplaces. Some studies have 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 (US) 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 [85]. Moreover, this same study found that being

Loading [MathJax]/jax/output/CommonHTML/jax.js educational attainment increased susceptibility Black

Americans could face to job displacement from automated systems [85, 86]. 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) [87]. Recent literature suggested that AI has the potential to exacerbate displacement for workers affected by automation [88–90]. What is more, 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 jobs that are at risk of job displacement [91]. It is important to highlight that data comparing gender groups finds that women are overrepresented in occupations (e.g., nurse, social worker, teacher) that have a greater requirement for emotional intelligence and could be less likely to be at-risk from displacement from AI or ML applications [92, 93].

Trend 3: AI-enabled human resource management systems

Increasingly, AI is being integrated into a growing number of human resource management systems including job applicant tracking, job matching selection software and human resource and performance management systems which intend on making fairer management decisions [50, 94–96]. 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 [97]. However, our review indicates that AI-enabled human resource management systems may collect personal information without explicit consent from the worker (e.g., disability status, lifestyle, age) and contribute to discrimination or the exclusion of certain groups according to their individual traits that are not relevant to the job rather than by their ability [98]. The potential for discrimination may stem from decisions made during the development of algorithms used to inform the initial parameters of an AI-enabled human resource management system [95, 99–101]. For instance, socioeconomic status, culture, and experience (e.g., White male non-disabled software engineers who may predominantly develop human resource management systems) can implicitly bias the development of human resource management systems and inadvertently reinforce gender, racial or disability biases [68, 102, 103]. What is more, unconscious biases have the potential to be reinforced through the application and testing of these system in non-diverse 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 behavioural 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 [104, 105]. 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 [104]. What is more, gamified assessments could also be more complex to accommodate for workers with disabilities [105]. Our review also found that AI-facilitated productivity systems that actively monitor and optimize productivity and outputs of workers could disadvantage persons with disabilities who have

physical or cognitive impairment and could perform job tasks in ways that differ from a pre-defined benchmark or may require job accommodations or adaptations to perform work responsibilities [79, 104].

Trend 4: Skill requirements for the future of work

Related to the digital transformation of the economy and 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. Surveys show that by 2022, at least half of employers report that their workers will be required to undertake significant reskilling or upskilling to adapted 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) [106, 107]. 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-enhanced systems within workplaces [14, 41, 82, 108–113]. At the same time, research suggested that some workers may lack the technological or soft skills required by employers in the future of work [114, 115]. A survey of 300 business executives in the US found that 87% of the workforce may be incorrectly anticipating the skills required for future employment [116]. Similarly, projections of Canada's labor force posit that by 2031 the country will experience a labor shortage of two million workers [117]. Shortages are expected to be highest in professions requiring training in science, technology, engineering and/or mathematics (STEM) [117].

When compared to population averages, groups that traditionally have been considered vulnerable workers like women, Indigenous peoples, people with low socioeconomic status and people living with disabilities are less likely to possess job skills that meet employer needs and may face more barriers to upskilling and reskilling opportunities, which may increase the digital divide [6, 118]. Vulnerable workers may also be more likely to experience barriers to accessing digital skilling programs that are needed obtain necessary technological competencies [65, 66, 68, 107, 118–122]. For instance, 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 the Indigenous community [123]. At the same time, literature uncovered in our scan indicates 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 [66, 124]. Research also suggested that skills and training gaps may result in employers being more likely to hire from a broader talent pool to address skills gaps [125, 126]. Accordingly, the future of work could be characterized by emerging opportunities for those who may have been traditionally excluded from the workforce [125, 126].

Trend 5: Globalization 2.0

In Globalization 2.0, the advancement of technologies in the future of work is catalyst for the global exchange of ideas, services and goods in both physical and virtual spaces across the globe as well as

increased interaction and integration of people, companies and governments [127–130]. Globalization 2.0 has contributed to a decreasing number of companies and workers across different industries (e.g., health care/social services, retail trades) being required to operate outside of the local jurisdiction in which goods and services are delivered [131]. As an example, studies 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 [64]. 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 [64]. Literature suggested that 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 would not pay local income taxes or contribute to social security and may be exempt from existing labor standards [65, 132, 133]. Some literature posited that the continued digital transformation of labor markets could result in those working in high-skilled occupations and where job tasks are more complex could also be at risk of displacement by tele-migrants. Additionally, the literature suggested that globalization may create adverse virtual working environments for workers for those who provide remote knowledge, expertise or services but will have less control over work conditions or their compensation [131].

Trend 6: Climate change and the green economy

The impact of 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 [134–137]. A synthesis of 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 (e.g., infectious disease, air pollution, heat-related illnesses) [137–149]. Workers within specific sectors (e.g., industrial services, agriculture, travel and tourism industries) are more likely to work outdoors and are considered to be particularly susceptible to climate change and extreme weather events [138, 139]. Research from the United States indicated that by 2100, six percent 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 [138, 139, 150–158]. While a shift to a green economy could mean that workers in certain industries (e.g., oil and gas) are at risk of job displacement, some researchers project that by 2030, with policy supports, up to 24 million new jobs could be created globally [159].

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 [140, 148]. 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 [140]. Several studies identified groups most affected by climate change including racialized communities, Indigenous peoples, youth and young adults, older adults, and those with low socioeconomic status) [140, 148]. For instance, we found that Indigenous persons may be especially affected by climate change because of their reliance on natural resources for financial, cultural, and physical well-being [140, 160]. Studies suggested that workers exposed to precarious work environments (e.g., seasonal or casual workers) or those employed in industries (e.g., farming, construction) are more susceptible to workplace health and safety hazards and interruptions to employment resulting from climate change [159]. 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 [161–163].

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-third of the labor market is composed of Gen Z workers [164–166]. 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 [76, 167, 168]. The positive impact of Gen Z workers on workplace can be attributed to 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 era where advanced digital technologies are commonplace [164, 169, 170]. Second, Gen Zs are also the most racially diverse generation in the workforce [171]. An analysis of US census data shows 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%) [169]. Third, the career trajectory of Gen Zs are more likely to have been shaped by the 2009 Great Recession and exposure to income inequality when compared to previous generations [166]. 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 [164–166]. For instance, a recent survey of over 1,531 Gen Zs found that over three quarters (77%) reported prioritizing employment in an organization whose values align with their own [164, 166].

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. Literature highlighted that Gen Zs desire to be employed in workplaces that value inclusiveness, diversity, and social responsibility, which could contribute to work environments that are more accessible to vulnerable groups [172–174]. Growing numbers of Gen Zs within the labor market could motivate employers to implement 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 [175–180]. 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 can address the digital divide [76, 166, 181].

Trend 8: Populism and the future of work

Hypothesized as stemming from both technological advancement and changes in 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 [182, 183]. Populism can refer to a diverse set of sociopolitical movements that include an antiestablishment orientation, broad anti-elite policies, and opposition to liberal economics and globalization [184]. At the time of this scan, political parties with populist views had grown in popularity in several industrialized countries (e.g., US, United Kingdom, France and Netherlands) [185–188]. Growth in populist values has been attributed to at least two expected future of work trends that have previously described in this paper – globalization 2.0 and the digital transformation of the economy [187]. First, although changes in globalization have contributed to economic benefits for employers and the governments [187], it has also partially contributed to an increased number of jobs being outsourced, offshored or filled by tele-migrants [182–184]. Second, advancements in digital technologies and their application within workplaces has meant that an increasing number of jobs have been displaced [90]. 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 [187, 189].

The growth in populist views has the potential to contribute to discrimination according to personal characteristics and exclusion of some groups of workers from the labor market. 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 [187, 190, 191]. The result are policy responses that may perpetuate populist values and may contribute an exclusion of traditionally vulnerable workers from higher quality employment opportunities (e.g., full-time and secure employment) [183, 188, 192, 193]. 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 [75, 90]. For instance, a recent survey of 1,995 Canadian workers examined how exposure to automation and AI could be 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 [90]. 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.

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 [194, 195]. The impact of the spread of working conditions is a prime example of an external shock that

has accelerated trends in the future of work. At the time of this scan, the COVID-19 pandemic had fast tracked numerous work-related trends highlighted in this horizon scan including companies increasing their investment towards diverse digital technologies to sustain productivity while also addressing potential workforce safety concerns (e.g., 3D printing, cloud computing infrastructures, robotics, virtual teleconference software and AI) [196–199]. In 2018, labor market estimates suggested that less than one-third of the US workforce were able to work from home and most of those were in higher paying and higher skilled jobs [200]. However, following the pandemic, several surveys found that up to two-thirds of workers in the US transitioned to a work-from-home arrangement [57, 159, 201, 202]. Studies indicated that the shift to work-from-home arrangements can have advantages (e.g., flexibility, opportunity to self-accommodate tasks) and disadvantages (e.g., isolation) for workers [203–205].

Of significance, the economic impact of the COVID-19 pandemic has had a disproportionately negative impact on traditionally vulnerable workers (e.g., certain racialized communities, low wage workers, and immigrants) [206–212]. Data from industrialized contexts indicated that these groups of vulnerable workers were disproportionately more likely to be employed in jobs at risk of exposure to COVID-19 and where health and safety protections were less likely to be provided [213–220]. As an example, a survey of 8,572 workers in the US found that the top quintile of earners were more likely to access a work-from-home arrangement (71%) compared to the bottom quintile of earners (41%) [210]. Data also suggests that 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 [211, 217, 221–228]. For instance, US labor force data indicates that occupations predominantly held by women were at least 1.8 times at greater risk of displacement from the COVID-19 pandemic compared to men [217, 229]. Also, in a survey of 4,917 US adults, Black (44%) and Hispanic (61%) respondents were more likely to report job or wage loss to compared to their White counterparts (38%) [229, 230]. 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 [57]. 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 [197, 211, 231].

Discussion

Involvement in paid work represents a critical social determinant to health. However, the conditions within the labor market are quickly changing in the future of work. The result could be work arrangements and work environments that are fragmented. While growing research has described the labor market impact of 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 of work trends that have unique challenges and opportunities for vulnerable workers. Our study provides a foundation for subsequent scholarship on social and health inequities that could emerge as a result of the future of work trends. Also, findings highlight potential policy and programmatic priorities that can ensure that

workers who have been traditionally excluded from the labor market can obtain opportunities for meaningful employment as working conditions change.

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 and work environments. Our horizon scan showed that the operationalization and measurement of vulnerability in studies of the future of work remains limited with few studies examining the interface between working conditions and characteristics of the worker. We highlight the need for additional research that aims to define and measure vulnerability and is relevant to research on the future of work. We found that the future of work could be marked by disparity. The trend categories we identified could have benefits for some groups of workers but also be harmful for others. Of particular concern, some groups of workers may enter the future of work at a position of disadvantage and could lack resources (e.g., access to upskilling opportunities) or be exposed to adverse working conditions (e.g., employment in occupations most susceptible to disruption) that impact their ability to navigate changes in the nature of work [232]. Indeed, the future of work represents a critical public health concern. The potential disadvantages faced by vulnerable workers could result in barriers to resources (e.g., income, health benefits, social support) that reinforce or widen health and social inequities. Interventions that promote the inclusion of vulnerable workers in the future of work represents an important pathway towards better health for the working population.

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 contribute to greater efficiency and productivity for employers [50] but could 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 the technical competencies, work in occupations with fewer advancement opportunities and face barriers to accessing reskilling programs. Studies conducted in the late 1980s and 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 [28, 129, 233]. Compared to past examples, current technological advancements are occurring at a faster pace and are disrupting a greater number of industries and occupations [6, 64]. 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 different digital technologies or particular AI/ML applications within the workplace may impact different groups of workers. Also, 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 [234]. Skills-based training should be tailored towards specific groups of workers who are more likely to experience vulnerability to ensure equitable workforce involvement [71].

Interestingly, we highlighted an intersection between technological innovation and social and political 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 influenced political sentiments [64, 90]. These sociopolitical shifts have the potential to exacerbate challenges faced by vulnerable workers. Our horizon scan can be contextualized using previous research showing that periods of technological advancement and growing globalization have contributed to wage depression and increases in precarious work that were more likely to increase levels of vulnerability for certain groups of workers [235–238]. It is expected that the rapid degree of technological change will further catalyze the sociopolitical trends we identified and increase their impact on vulnerable workers. Additional research within multidisciplinary teams is required to further unpack how the relationship between technological change, sociopolitical shifts and specific work experiences and are conditions experienced by different groups of workers.

Importantly, our scan highlighted some opportunities for traditionally vulnerable workers in the future of work. The digital transformation of the economy, AI/ML applications that increase productivity, growing access to work-from-home arrangement, and an emerging green economy will create new jobs that will demand workers with specialized technical and soft skills, and serve as an entry point for worker into the labor market of the future. Our review also found that those working in certain occupations or in specific work environments may be less likely to be disrupted by digital technologies or automated systems [239]. What is more, a generational shift in the workforce (i.e., decreasing Baby Boomers and growing Gen Zs in the labor market) has the potential to foster inclusive employer practices. It is unclear to what extent vulnerable workers will experience barriers or facilitators to accessing the potential opportunities within the context of the changing nature of work. Research is required to elaborate on our study findings to further examine the extent to which vulnerable workers may access opportunities in the future of work and address anticipated labor market shortages [71, 240]. Furthermore, identifying opportunities in the future of work represents an important direction to meet the UN's Sustainable Development Goal #8 of Decent Work. Policy responses that are tailored to vulnerable worker to promote access to high quality employment opportunities and barrier-free working conditions can be critical in ensuring decent work and productivity.

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 many of the trend categories that we identified and may exacerbate challenges and opportunities faced 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 in the late 2000s were more likely to contribute to loss of employment, income inequality and an erosion of standard work opportunities for certain groups of workers (e.g., youth, low skilled workers) [241]. Markedly, numerous studies also show that the Great Recession contributed to detrimental physical and mental health

Loading [MathJax]/jax/output/CommonHTML/jax.js experienced by vulnerable workers, especially in contexts with

weak social and health protections [242–245]. 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 [195]. Continued scanning of new trends is required to continue 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 are protected from 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 literature on the future of work to identify salient trend 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 changes 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 by changes 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 we uncovered. As a result, we take a broader perspective towards vulnerability and examine how the future of work could impact work arrangements and work conditions. It is important to highlight the heterogeneity of experiences faced by different workers. Accordingly, studies are needed to capture the diverse challenges and opportunities for specific groups who have been traditionally 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 exacerbate susceptibility to displacement and disadvantage in the future of work [85, 246]. Additional research applying an intersectional lens could elaborate on the overlapping identities and macrolevel structures that may contribute to inequalities.

Conclusion

The future of work represents 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. Notably, exclusion from the future of work has the potential to widen existing social and health inequities already facing vulnerable groups of workers. Overall, our study provides an important first step in understanding the work and health implications of the future of work and directs research and practice towards a focus on vulnerable workers.

Abbreviations

3D = Three dimensional

AI = Artificial intelligence

Loading [MathJax]/jax/output/CommonHTML/jax.js

AR = Augmented reality

ML = Machine learning

STEM = Science, technology, engineering, mathematics

UN = United Nation

US = United States

VR = Virtual reality

Declarations

Ethics and consent to participate

No primary data was collected as part of this horizon scan.

Consent for publication

Not applicable

Competing interests

CN is the principal and president of Cense LTD. CN has no financial or personal conflicts of interest related to the study. No other authors have competing interests related to this research to report.

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Availability of data and materials

No data was collected as part of this study. The search terms we have utilized in this horizon scan have been included as a supplement

Author contributions

AJ and AS conceived the study idea. AS, AJ, SB, MG, LT, ET, UB, CN, CB, PS led the development of the methodology. AJ and AS implemented the study methodology and led data collection and analysis. All authors substantially contributed to the writing of this manuscript.

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Figures

Figure 1

Review flow chart

Figure 1

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