



The future of research on work, safety, health and wellbeing: A guiding conceptual framework

Glorian Sorensen^{a,b,*}, Jack T. Dennerlein^{b,c}, Susan E. Peters^{a,b}, Erika L. Sabbath^d, Erin L. Kelly^e, Gregory R. Wagner^b

^a Dana-Farber Cancer Institute, Boston, MA, USA

^b Harvard T.H. Chan School of Public Health, Boston, MA, USA

^c Bouvé College of Health Sciences, Northeastern University, Boston, MA, USA

^d Boston College School of Social Work, Chestnut Hill, MA, USA

^e MIT Sloan School of Management, Cambridge, MA, USA

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ABSTRACT

Work plays a central role in health. A conceptual model can help frame research priorities and questions to explore determinants of workers' safety, health, and wellbeing. A previous conceptual model focused on the workplace setting to emphasize the role of conditions of work in shaping workers' safety, health and wellbeing. These conditions of work include physical, organizational, and psychosocial factors. This manuscript presents and discusses an updated and expanded conceptual model, placing the workplace and the conditions of work within the broader context of socio-political-economic environments and consequent trends in employment and labor force patterns. Social, political and economic trends, such as growing reliance on technology, climate change, and globalization, have significant implications for workers' day-to-day experiences. These structural forces in turn shape employment and labor patterns, with implications for the availability and quality of jobs; the nature of relationships between employers and workers; and the benefits and protections available to workers. Understanding these patterns will be critical for anticipating the consequences of future changes in the conditions of work, and ultimately help inform decision-making around policies and practices intended to protect and promote worker safety, health, and wellbeing. This model provides a structure for anticipating research needs in response to the changing nature of work, including the formation of research priorities, the need for expanded research methods and measures, and attention to diverse populations of enterprises and workers. This approach anticipates changes in the way work is structured, managed, and experienced by workers and can effectively inform policies and practices needed to protect and promote worker safety, health and wellbeing.

1. Introduction

Work plays a central role in determining health. It provides wages and benefits, shapes life opportunities and resources for individual workers, their families and communities, and may enhance wellbeing, resilience and life satisfaction. Alternatively, working conditions – whether physical exposures, job demands, or psychosocial experiences – may cause or contribute to work-related injury and illness and may increase risk of chronic disease and mental distress. A growing body of research is seeking to understand these intersecting pathways through which work functions as a key social determinant of health (Hudson et al., 2019; Pfeffer, 2018; Anger et al., 2015; Kelly and Moen, 2020;

Lovejoy, Kelly, Kubszansky, Berkman; Fox et al.).

A conceptual model can assist in framing research hypotheses and priorities to explore determinants of workers' safety, health, and wellbeing. Our previous conceptual model focusing on the workplace setting is centered on the conditions of work, driven by organizational policies, programs and practices within the context of enterprise as well as worker characteristics (Fig. 1) (Sorensen et al., 2016). Physical, organizational, and psychosocial conditions at work contribute directly to worker safety, health, and wellbeing (Schulte et al., 2019), and influence enterprise outcomes such as turnover, absence, productivity, and healthcare costs (Goh et al., 2016; Bloom et al., 2015; Williams et al., 2018a). The model also illustrates causal pathways through which

* Corresponding author. Dana-Farber Cancer Institute, 450 Brookline Avenue, Boston, MA, 02115, USA.

E-mail address: Glorian.Sorensen@dfci.harvard.edu (G. Sorensen).

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workplace policies, programs, and practices may influence worker and enterprise outcomes, highlighting the importance of organizational interventions that improve working conditions.

The original conceptual model is limited, however, by its exclusive focus on the workplace without explicit attention to the broader context in which work is situated. Socio-economic trends, such as growing reliance on technology and globalization, directly affect workers' day-to-day work experiences. For example, increasing globalization may re-structure supply chains, heightening productivity demands and increasing the pace of work. "Just-in-time" approaches to production, in which staffing levels are based on real-time workload rather than being set in advance, diminish predictability of workers' schedules. With growing job demands and long work hours, workers may face mounting stress-related health outcomes and heightened injury risk.

The broader context of work also includes the structure of employment relationships, which has changed significantly in recent decades (Weil, 2014). A growing literature in the scientific and popular press has hypothesized and documented how these changes may influence patterns of employment and unemployment, work experiences, and workers' health outcomes (Schulte et al., 2019; Scully-Russ and Torraco, 2020; Lund et al., 2019). For example, few workers have a single employer throughout their working lifetime; instead, in the face of stagnant wages, many workers balance more than one job at a time and frequently switch employers. The increasing complexity and diversity of work arrangements results in a range of new risks to workers, often accompanied by fewer protections, but may also offer potential for envisioning new and better ways to work (Schulte et al., 2019; Schulte et al., 2015).

A research agenda that informs efforts to promote and protect worker safety health, and wellbeing must incorporate these changing and evolving patterns in the ways that work is structured, managed, and experienced by workers (Stacey et al., 2018; Hayter, 2020). Even before the COVID-19 pandemic, there was increasing recognition of the potential implications of rapid technological change, globalization, climate change, and changing demographics for reshaping work (Schulte et al., 2019). The pandemic has accelerated some trends, increasing the urgency to determine creative ways to plan and conduct research responsive to the changing nature of work and the blurring of boundaries between work and other life domains (Hayter, 2020; Scoblic, 2020). The dynamic and often unpredictable nature of these changes, and the complexity of systems in which work is embedded, requires a framework responsive to evolving working conditions, workforce demographics, and employment relationships.

The purpose of this paper is to present an expanded conceptual model, grounded in the conditions of work, to frame research that responds to these emerging trends (Fig. 2). Placed within the enterprise itself, modifiable conditions of work remain central to the model as drivers of outcomes for both workers and enterprises. In the expanded

model, these conditions of work are placed within a broader context to reflect the dynamic system influencing how work is performed, the technologies employed, and the nature of employment relationships.

The adaptation of the original model was informed by a comprehensive literature review conducted by the authors to explore research opportunities relative to the future of work. The expanded model was presented in June 2020 at a virtual workshop entitled "Shaping the Future to Ensure Worker Health and Wellbeing: Shifting Paradigms for Research, Training, and Policy," organized by the University of Texas Health Science Center at Houston/School of Public Health in collaboration with the National Institute for Occupational Safety and Health.

2. Forces influencing work, safety, health and wellbeing

This section describes forces potentially operating at each of the layers of influence and how changes underway at each level raise questions needing to be addressed as investigators and policy makers consider ways to protect and promote worker safety, health and wellbeing as work evolves (Table 1). The description of the model begins at its outer edges to first understand the larger forces that shape working conditions in order to envision sustainable change in those conditions. Our discussion draws predominantly on examples from the scientific literature focused on the United States and other high-income countries, although systems, forces, and circumstances captured in the model have broader global relevance.

2.1. Socio-political-economic environment

Social, political, and economic environments include structural forces that influence employment and labor patterns, shape working conditions at the enterprise level, and ultimately impact worker safety and health as well as enterprise outcomes. These forces include what the International Labor Organization (ILO) has called "megatrends:" globalization, technology, demography and climate change (International Labour Orga, 2020). Additionally, we consider the potential effects of changing patterns of disease distribution; demographics and social inequalities; and the policy and regulatory environments that are indicative of governments' stances on protecting worker safety, health, and welfare.

Globalization: Increasing internationalization of financial markets and trade has implications for global production patterns. Production tasks are increasingly fragmented as global supply chains expand and costs related to trade and transport decline (International Labour Orga, 2020). For example, jobs may be outsourced within supply chains so that the lead enterprise may no longer be responsible for employing those producing the goods or services, thus reducing employer accountability for safe working conditions (International Labour Offi, 2016; Schnall et al., 2016). Increasing global competition may pressure employers to

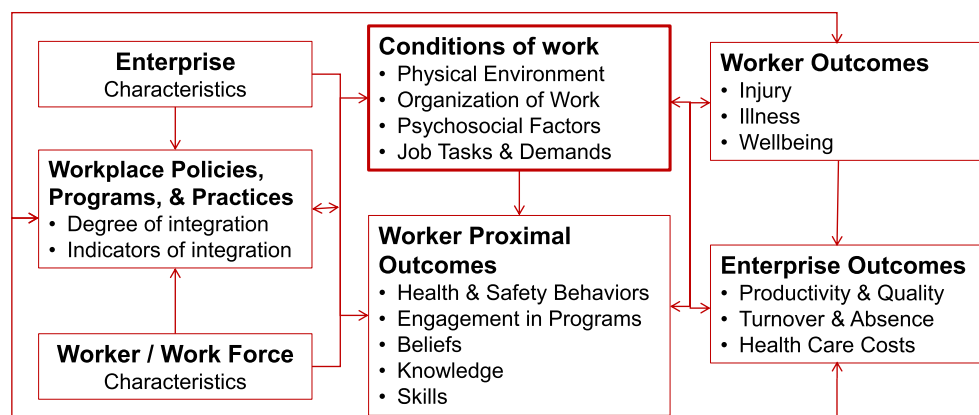


Fig. 1. Conceptual model for integrated approaches to the protection and promotion of worker health and safety (Sorensen et al., 2016).

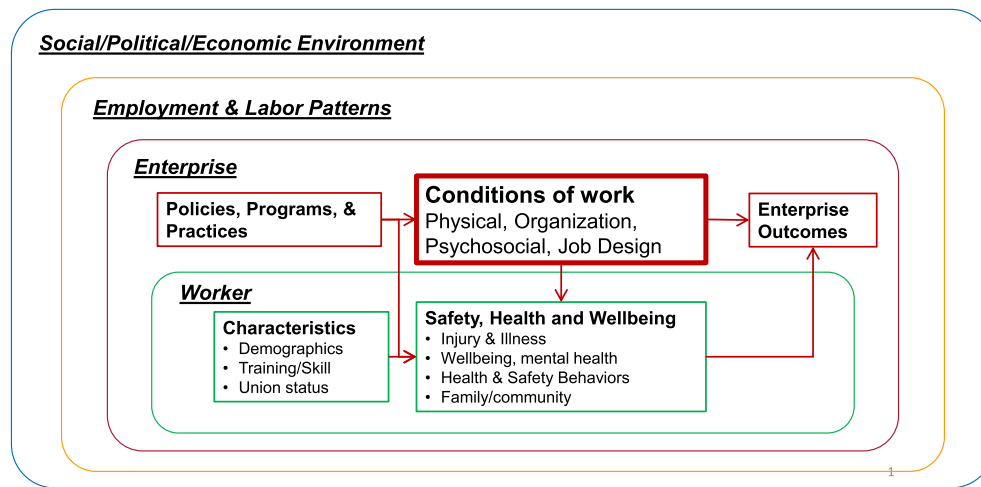


Fig. 2. Expanded conceptual model.

Table 1
Sample model components and hypotheses, by level.

| Level of the Model | Sample Components | Sample Hypotheses |
|---------------------------------------|--|--|
| Socio-political-economic | Globalization Technology Climate change Changing distribution of disease Demographics Social inequalities Policy and regulatory environments | <ul style="list-style-type: none"> Improved health and safety outcomes for workers will be observed in states implementing mandatory increases in the minimum wage compared to those states without such increases. |
| Employment and labor patterns | Distribution of jobs Employment stability Non-standard work arrangements Worker protections Worker voice | <ul style="list-style-type: none"> Workers reporting having more than one employer will report decrements in health and safety outcomes compared to workers having only one employer. |
| Enterprise: Conditions of Work | Physical Working Conditions: Organization of work Job design Psychosocial work environment Policies, programs and practices | <ul style="list-style-type: none"> Workers reporting increasing intensification of work, longer work hours and inflexible schedules will report higher injury rates and lower wellbeing. |

re-structure work for heightened efficiency, often resulting in increased work pace, changes in scheduling and staffing, and reduced investments in workers' safety protections (Howard, 2015). Pressures to reduce costs may result in both declining wages and diminished investments in health and safety protections (Boden et al., 2016).

Technology: New technologies – ranging from artificial intelligence and robotics to the use of Big Data, among others – shape patterns of economic growth and development, contributing to significant changes in the labor market as well as working patterns (Schulte et al.; Boden et al., 2016). For example, analytic tools allow employers to manage logistics and anticipate consumer demand, thereby re-structuring production flow and enabling last-minute adjustments to worker schedules. Consequently, workers may have less predictable and reliable schedules, complicating their ability to balance work requirements with competing demands from family, caretaking, or second jobs (Boden et al., 2016). Mobile technology has made it easier for workers and enterprises to undertake non-standard work arrangements through on-demand

business platforms. For some jobs, technology has increased the ease of working remotely (Stacey et al., 2018). The COVID-19 pandemic has accelerated many of these changes, dramatically increasing reliance on remote work and increasing use of technology-dependent delivery services (Hayter, 2020).

Automation increases productivity and output, and creates new jobs, although these jobs are not evenly distributed by sector, gender or skill level. New technologies may also result in changes in job quality and displacement and increase competency obsolescence; resulting gaps in skills may increase the need for continuous education and training of workers (Schulte et al., 2019; Stacey et al., 2018; Schulte, 2020).

Climate change: As a consequence of growing sustainability pressures, significant changes are needed to meet climate change targets, including reductions in emissions and new patterns of consumption and production. A transition to a sustainable economy will require shifts in jobs, away from carbon producing and utilizing industries, and adaptation of existing jobs to fit the needs of a greener economy. Climate change may also have direct implications for workers who work outdoors and experience increasing temperatures and more frequent exposure to extreme weather events (Hayter, 2020; Schulte et al., 2016).

Changing distribution of exposure and disease: While disabling injuries and fatalities from work continue to take a significant toll on workers, equally important is the role of workplace exposures in the risk of non-communicable disease such as cancer and heart disease. Consistent evidence underscores the contributions of the work to behaviors that are associated with chronic disease risk, such as tobacco use, physical inactivity, and sleep deficiency (Hudson et al., 2019; Pfeffer, 2018; Sorensen et al., 2016). The COVID-19 pandemic has additionally highlighted the importance of infection risk at work and disparities in workers' exposures to work-related hazards, with frontline workers (including healthcare workers and others unable to work from home) at increased risk for COVID-19 (Rothwell, 2020; Dennerlein et al., 2020).

Changing demographics and social inequalities: Socio-political-economic environments shape who is employed and the types of available jobs (and attendant exposures and benefits), based on socioeconomic position, race/ethnicity, gender, age, nationality, nativity, immigration, citizen status, sexual orientation, and gender identity, among other factors (Krieger, 2010). Age provides a useful illustration. In high-income countries such as the U.S., the overall aging of the population contributes to increasing age of workers and an increase in the old-age dependency ratio (the ratio of people over age 65 relative to those 15–64) (Li et al., 2018; Sudharsanan et al., 2018). This shift may place increased burdens on those in the labor force to care for elders. Longer life expectancy may also have implications for employment

opportunities and needs within some emerging sectors, such as health care or long-term care (International Labour Orga, 2020). With a rising retirement age, the aging workforce may heighten the need for accommodations and attention to their differing needs and potential risks.

Individuals' work experiences are further shaped by histories of exclusion and marginalization (Berkman et al., 2014). Racial and ethnic minorities comprise a considerable percentage of the U.S. workforce ($\approx 22\%$) and are over-represented in non-standard precarious work arrangements, have elevated rates of unemployment and are often employed in low-wage occupations with a excess burden of adverse exposures (Quinn et al., 2007; Bureau of Labor Stat, 2018). The COVID-19 pandemic has highlighted the extent to which higher-risk, less-stable jobs are disproportionately held by immigrant workers and workers of color (McClure et al., 2020). A growing body of research has also demonstrated that conditions of work, including job insecurity and high job strain, contribute to inequalities in lifespans (Goh et al., 2015) as well as other poor health outcomes such as cardiovascular disease and accelerated cognitive aging (Sabbath et al., 2016). This burden of work-related disease may in turn have implications for economic performance contributing to economic and political instability, potentially discouraging investments in new jobs (Ostry et al., 2015).

Policy and regulatory environments: Both governmental and enterprise-specific policies have a significant influence on working conditions that in turn affect worker health, safety, and wellbeing. These policies develop in response to scientific information and social and political pressure within an economic and legal framework and are embodied in mandatory regulations as well as voluntary guidelines (Wagner et al., 2017). In recent years, the politically dominant philosophy of deregulation in the U.S. and elsewhere has favored the removal of regulatory restrictions on businesses and increased reliance on employers choosing to provide worker protections over mandatory regulations enforced through aggressive inspections. While regulatory strategies are critical, some "high road" employers have embraced their responsibilities to the communities in which they operate, the customers they serve, and the workers they employ (Business Roundtable, 2020; Osterman, 2018).

Other social protection policies are also limited. For example, the federal minimum wage in the U.S. has been fixed at \$7.25/hour for over a decade, despite being eroded by inflation, although individual states and municipalities have legislated increases in minimum wage. Nationally, workers have been guaranteed the right to take time off for extended illness, childbirth, or to care for a sick family member through the Family and Medical Leave Act; however, there is no right to be paid for taking this leave. And, despite the intent of the Affordable Care Act to assure at least a minimum level of health insurance for all U.S. citizens, most insured people continue to rely on their employers for insurance, and millions remain uninsured. Furthermore, the public health infrastructure has been chronically underfunded, a deficiency that has become evident in the halting and often inadequate U.S. response to the COVID-19 pandemic. Going forward, there is uncertainty about the political will to fund improvements in the social safety net that would modify working conditions and policies to improve health, safety, and wellbeing of workers and their families.

2.2. Employment and labor patterns

Social, economic, and political forces in turn shape employment and labor patterns, with implications for availability and quality of jobs; the nature of relationships between employers and workers; and benefits and protections available to workers (Hayter, 2020). Although scholars and policymakers have spent considerable effort describing these changes, the COVID-19 pandemic and accompanying economic consequences may accelerate these trends and promote the emergence of new employment patterns, as the following examples illustrate.

Distribution of jobs: Re-distribution of jobs across industry, occupation and size of organization is already underway (Hayter, 2020).

Emerging technologies are expected to displace some workers, while creating new kinds of jobs for others (Howard, 2019). Growth in some jobs, such as home health care and delivery services, may be in isolated settings with limited opportunities for social interactions (Boden, 2020). Climate change pressures may similarly create new opportunities in the green economy as well as different health and safety risks such as those related to heat, extreme weather events, and changes in patterns of vector-borne infections (Schulte et al., 2016).

Employment stability: Changes in employment stability are expected to result in increases in precarious and temporary work, unemployment, and turnover (Kalleberg, 2013). Whether sufficient jobs will be created for those seeking employment in coming years depends on the balance between job destruction as a result of technology changes versus increased innovation in other sectors that results in new jobs (Hayter, 2020; Howard, 2019). Many workers may suffer from lost or lower wages due to adoption of new technologies. Precarious work creates income instability and insecurity, stress related to the period of unemployment between jobs, and is often accompanied by fewer safety protections and health benefits (Benach et al., 2014; Kalleberg, 2018). Temporary workers are less likely to receive training for the job and thus may be more vulnerable to workplace hazards than longer-term employees (Boden, 2020).

Non-standard work arrangements: Discussions of the future of work have given significant attention to non-standard work arrangements such as contingent, contracted or outsourced work; franchising; and platform business models seen with gig workers (Weil, 2014). Multi-employer workplaces are becoming more common across different sectors. These working arrangements have evolved as employers seek to limit their statutory responsibilities and financial liabilities while increasing their flexibility in employment relations, blurring lines of accountability for workers' health and safety. Separation of control of the work environment from the employment relationship may threaten worker health and safety (Boden et al., 2016). Yet for some workers, non-standard work arrangements provide increased scheduling flexibility, potential for more autonomy, and improved work-life balance for those with family responsibilities (Hayter, 2020).

One example of non-standard work arrangements is among gig workers or self-employed workers, such as in construction, who are classified (or sometimes misclassified) as independent contractors. As such, they are often exempt from minimum wage guarantees, and their employers do not provide retirement plans or health, disability, or unemployment insurance (Hayter, 2020). These workers often have fewer protections, less job security, limited training, and poorer working conditions than others.

Similarly, worker health and safety may be influenced by economic pressures on contracting employers and short tenures of workers in high-risk jobs (Boden et al., 2016).

Worker protections: Concurrently, worker protections are declining as a consequence of decreased regulation and regulatory effectiveness (Schulte et al.). Federal agencies responsible for inspecting workplaces and enforcing regulations intended to protect workplace health and safety face diminished funding, reduced numbers of inspectors, and decreased sanctions for noncompliance. In the US, OSHA has been criticized for failure to respond to workers concerned about the lack of COVID-19 protections at work and its unwillingness to issue an emergency workplace standard in response to the pandemic (Michaels and Wagner, 2020). In addition, the Wage and Hour Division of the U.S. Department of Labor has reduced the number of personnel enforcing minimum wage protections over the last decade.

Worker voice: These trends are exacerbated by the declining role of organized labor and decreasing worker input and ability to voice concerns about risks (Greenhouse, 2019). The strength and density of unions or worker advocacy groups may also influence the balance of power between labor groups and employers; in 2019, only 7% of private sector employees in the U.S were covered by collective bargaining agreements (Bureau of Labor Statistics, 2019). Furthermore, existing

labor laws often do not provide adequate protections from retaliation for workers in traditional employment relationships who raise concerns about violations of their rights. Union representation may result in more equitable power balance at work, resulting in improved regulatory enforcement and reduced fatalities (Morantz, 2011); however, current laws are inadequate to protect workers with non-standard work arrangements and may preclude union representation (Boden et al., 2016).

2.3. Enterprise: Conditions of work

The majority of workers continue to be employed directly by an identifiable, specific employer/enterprise (Bureau of Labor Statistics, 2019). Conditions of work play a central role within the enterprise as proximal determinants of workers' safety, health and wellbeing, although working conditions are equally important for those working in non-standard arrangements. Policies, programs, and practices may follow several pathways to improve conditions of work and protect and promote worker safety, health and wellbeing, while also contributing to positive outcomes for the enterprise. Importantly, the experiences of employers who pay better, involve workers in decisions regarding work processes and technologies, and promote employee-driven flexibility along with more predictable schedules demonstrate that this "high road" approach can and does improve productivity and quality, increase retention, and create strategic advantages and greater profits for firms (Rahmandad and Ton, 2020; Litwin et al., 2018). These conditions of work are modifiable – and even within the context of the contemporary socio-political-economic environment and shifting employment and labor patterns, some work organizations have prioritized health-supportive working conditions and still thrived financially (Cappelli and Neumark, 2001; Ton, 2014).

Physical conditions of work: The field of occupational safety and health has historically focused primarily on the physical work environment, aiming to protect workers from exposures to chemical, physical and biological hazards. Adoption of new technology will result in new exposures due to changes in the human-machine interface, while also introducing potential innovations in risk assessment. Exposures in emerging occupations, such as nanomaterial production and application, may present novel risks. Where workers spend their time has already shifted during the COVID-19 pandemic, with increased numbers working from home. While for some this shift is temporary, for many it may become permanent. In addition, it will be important to monitor the potential synergy and accumulation of exposures across occupational settings as workers are employed in an increasing number of jobs over their careers (Hayter, 2020).

The organization of work: Increasing competition related to globalization and rising production pressures are intensifying the pace of work and workload. Workers in temporary or precarious jobs usually have limited control over the pace of work, are hired in periods of high work demand, and often have few supports within the workplace, all of which are associated with injury risk and threats to wellbeing (Boden, 2020; Peters et al., 2018). Without pressure of federal regulations and enforcement to assure minimum standards, there is potential for work to offer fewer benefits, lower pay, and less protection (Schulte et al., 2019; Boden et al., 2016).

Job design: The design of a job, including tasks, work processes and demands, work hours and shifts, and the extent to which physical, cognitive and emotional efforts are requirements of the job, influences a range of safety, health and wellbeing outcomes (Sorensen et al., 2016). Increased telecommuting and changes in the distribution of jobs, including increasing employment in the service sector and in non-standard work arrangements, are likely to result in the potential for less predictable scheduling and either inadequate hours or longer hours (Lambert et al., 2014; Schneider and Harknett, 2019). Dimensions of work intensity that contribute to overload include long work hours, the need for "always-on" availability, demands for multi-tasking that splits attention and focus, and expectations for face time, with significant

implications for workers' health, safety and wellbeing (Kelly and Moen, 2020). Emerging technologies and task automation may contribute to mis-alignment between workers' skills and task requirements and intensify mental overload (Schulte et al., 2019; Schulte et al., 2015; Howard, 2019).

The psychosocial work environment includes factors such as job strain, psychological demands and control (Karasek and Theorell, 1990), social support (Choi and Pak, 2006), exposure to harassment and discrimination (Sabbath et al., 2018a), and safety and health climate. With increasing non-standard work arrangements workers may have fewer opportunities to develop social ties and support (Weil, 2014; Benach et al., 2014). Workers in short-term and seasonal jobs may experience stress as a consequence of higher job demands and uncertainty about future job prospects, increasing threats to mental health and wellbeing (Schulte et al., 2019; Benach et al., 2014). Economic pressures on an enterprise may lead to increased emphasis on production over safety, either explicitly or implicitly. Maintaining psychological safety at work, cultivated through strong leadership and teams, is not only important for worker mental health but also important for optimizing organization performance. Nonetheless, higher levels of job precarity pose threats to psychological safety at work (Edmondson, 2018).

Organizational policies, programs and practices: Policies, programs, and practices are positioned in the model as important points of intervention that may contribute to improvements in conditions of work and ultimately to worker safety, health and wellbeing. Employers may directly foster these supportive policies, programs, and practices, and also support these actions by leadership commitment, participatory practices, collaborative and comprehensive approaches, and data-driven approaches (Sorensen et al., 2018). Studies focusing on organizational change provide significant promise in modifying conditions of work in support of workers' health, safety and wellbeing (LaMontagne et al., 2014; Nielsen and Abildgaard, 2013). Participatory practices offer workers opportunities to identify specific problematic working conditions and also allow managers to listen to workers concerns and work collaboratively with key stakeholders to make these changes, benefiting the organization as well as workers who feel greater agency and control. New approaches to participatory engagement of workers may be needed for workplaces that include subcontracted and temporary workers, such as construction sites with workers reporting to different employers of record (Peters et al., 2020), suggesting a fertile area for future research. Stable scheduling and staffing practices serve as another example of organizational changes that can support workers' wellbeing, reflecting the realities of caregiving in a more diverse society. Here, too, employers can shift policies and practices to benefit worker wellbeing and enterprise outcomes such as improving productivity and reducing turnover and associated costs (Kelly and Moen, 2020; Williams et al., 2018b; Worklife Law, 2020).

2.4. Outcomes for workers and enterprises

Understanding the implications of changes in work for workers' safety and health will require attention to an expanded range of outcomes.

Worker safety, health and wellbeing: Future research will need to move beyond traditional occupational health outcomes of reducing work-related injuries and illnesses and towards examining ways work determines and shapes positive health and wellbeing outcomes. This expanded perspective is already underway with guidance from the Total Worker Health® Program of the National Institute for Occupational Safety and Health (NIOSH) (Schill and Chosewood, 2013), the WHO Workplace Health Initiative (Burton, 2010), United Kingdom based-programs (Health Service Executive (HSE), 2020), and beyond (Litchfield et al., 2016). Future research must also address multi-factorial pathways and outcomes, given the increasing complexity of people's work arrangements, exposure profiles, and the work-home

interface (Schulte et al.).

Research emphasizing relationships between work and wellbeing, quality of life, burnout and other indicators of mental health is needed (Fox et al.; Krekel et al., 2019). Work, or its absence, has profound effects on the health, happiness, and physical and psychological wellbeing of both individuals and populations. Working conditions and policies linked with worker happiness, wellbeing, and good health include co-worker and supervisor support; physical safety; psychological safety; a sense of purpose; balance between work demands and the time, training, and tools to accomplish them; remuneration; commute times; and policies permitting balance between workplace and out-of-work demands (Lovejoy, Kelly, Kubszansky, Berkman; Fox et al.). Although the benefits from supportive working conditions are clear in some populations, it is less clear how generalizable these findings are to those with inadequate education or training, physical or cognitive disabilities, and limited work experience. Additional research will help identify specific conditions at work supportive of the wellbeing of workers during both their working time and their lives beyond work (Fox et al.). The improved understanding of working conditions and practices that are associated with workers' thriving can lead to testing interventions that may advance worker wellbeing as well as outcomes important to the employing enterprise (Schulte et al., 2015).

Enterprise outcomes: Research on implications of the future of work will also benefit from attention to employer-relevant, or enterprise, outcomes. Such research is needed to determine potential incentives that would prompt employers to consider changes in workplace policies, programs and practices, in addition to informing social/governmental policies. A business case for protecting and promoting worker safety and health will be necessary to ensure that employers make investments to improve conditions of work, including recognition of the industries and business strategies under which greater investments in workers pay off (Osterman, 2018; Rahmandad and Ton, 2020). Prior research indicates that health care costs and workers' compensation premiums are directly related to workers' experiences of stressors such as bullying at work (Goh et al., 2016; Sabbath et al., 2018a), and that work scheduling may have significant implications for turnover (Williams et al., 2018a; Moen et al., 2017). Job accommodations that help injured or chronically ill workers stay at work and, when ready, return to work following temporary disability, can reduce unscheduled work absences and disability costs (Shaw et al., 2018). When employers demonstrate commitment to worker wellbeing through supportive policies and improved working conditions, additional benefits may accrue, such as improved job satisfaction, worker engagement, and reduced employee turnover (Osterman, 2018; Rahmandad and Ton, 2020; Balogun et al., 2020). Of note, enterprises that have been recognized for achievements in worker safety, health and wellbeing have shown better stock market performance than the Standard and Poor's 500 indices, although evidence of causality needs to be developed further (Fabius et al., 2016; Grossmeier et al., 2016).

3. Research implications

The conceptual model presented here uses a systems framework to anticipate research needs and intervention priorities in response to the changing nature of work (Sorensen et al., 2016; Bradley et al., 2016; Punnett et al., 2009; Schulte et al., 2012). We previously used our conceptual model in both our epidemiologic and intervention research - as a framework to conceptualize our intervention logic model, and to generate and test hypotheses (Peters et al., 2018; Sorensen et al., 2019). In the Boston Hospital Workers Health Study, we explicitly use the model to guide our hypothesis development (Sabbath et al., 2018a, 2018b), and across manuscripts to unite our inquiries into a coherent body of research (Sabbath et al., 2018c) in which the conditions of work are central determinants of worker health and wellbeing.

3.1. Establishing research priorities

This conceptual model highlights the need for research to consider critical factors beyond the workplace that nevertheless have direct and indirect effects on worker health. The model emphasizes the importance of broad social, economic and political trends in shaping the evolution of work in order to understand how these changes affect worker safety, health, and wellbeing directly and through influencing the adoption of workplace policies, programs, and practices by employers and decision-makers in organizations. It provides a framework for developing research questions and hypotheses across diverse levels of influence. Sample hypotheses are included in Table 1.

3.2. Study methods

With these expanding research questions, it is increasingly important to employ a wide range of research designs and methodologies (Tamers et al., 2018). For example, while basic and etiologic studies are needed to identify evolving risks related to new types of exposures, social epidemiological methods are critical for understanding the effects of organizational and psychosocial exposures (McClure et al., 2020; Krieger et al., 2008). As individual employers become more data-driven, administrative data from individual organizations can be harnessed for epidemiologic research (Sabbath et al., 2018c). Surveillance tools are needed to monitor emerging risks and potential outcomes for workers and enterprises. Changes in work will require new research methods for electronic follow-up of workers across jobs and settings, while also determining ways to anticipate and address issues of privacy, attrition, and potential selection bias.

Intervention research will need to employ a full range of designs, including formative research or pre-experimental methods development (Tamers et al., 2018); intervention effectiveness research using both quasi-experimental and randomized designs (Murray, 1998; Olsen et al., 2008); observational studies that track the course of natural experiments and program evaluations (Schelvis et al., 2015); case studies that highlight both successes and challenges in intervention implementation (Yin, 2014); and community-based participatory research methods and related approaches that ensure that workers and other stakeholders have a voice in research and intervention priorities (Cherniack et al., 2019). Process evaluation that can capture the extent to which interventions are delivered as planned as well as identify barriers and facilitators encountered will help to inform improvements in intervention implementation and effectiveness (Nielsen and Abildgaard, 2013; Linnan and Steckler, 2002).

Policy research will be needed to contribute to assessment of effects and effectiveness of regulations and public and enterprise-specific policies. This research will be instrumental in moving research findings into practice through the adoption of both public/governmental policy and regulations as well as through the voluntary embrace of guidelines and recommendations by sectors and individual employers.

In addition, research to determine or evaluate strategies for sustaining, translating, and disseminating evidence-based interventions will rely on methods from the burgeoning field of dissemination and implementation science (Schulte et al., 2017; Dugan and Punnett, 2017).

3.3. Measures and metrics

These expanded research directions will need to use both quantitative and qualitative data and employ mixed methods (Creswell et al., 2011). Opportunities enabled by analysis of "big data" via machine learning and other sophisticated analytic techniques will provide new insights into exposure-outcome relationships, with metrics and measures evolving in response (Mayer-Schoneberger and Cukier, 2013; Na and Kim, 2019). Transdisciplinary approaches incorporating new measures and methodologies adapted from diverse disciplines (e.g. econometrics, social network analysis) are critical to exploring these complex

systems. (Schulte et al., 2019; Howard, 2019).

The long-standing focus on workplace injury and illness is expanding to examine the contribution and benefit of work on positive human functioning. Instruments and metrics that allow assessment of improvements in positive functioning and worker wellbeing are needed (Chari et al., 2018). Measures need to be sensitive to the evolving work and worker landscape and may require continued validation across sectors as the nature and pattern of work changes (Litchfield et al., 2016).

3.4. Study populations and samples

The representativeness of samples of both workers and enterprises determines the generalizability of research findings. Changes in job distributions, demographics, and technology will determine shifts in samples to be included in future research. Attrition at either the enterprise or worker level can contribute to selection bias, threatening the validity of research inferences (Manjourides et al., 2018). Mergers, downsizing, turnover and other factors may influence the ability to follow employers and workers over time (Tamers et al., 2018). Furthermore, selection of healthy workers into the workforce and the likelihood that healthy workers stay at work longer than those who are injured or made sick from work may reduce the potential to identify adverse health effects from work or erroneously enhance the appearance of benefits from work. Accordingly, research will need to use appropriate analytic techniques and also, to the extent possible, ensure effective representation across these settings.

Rising employment through contracting agencies, often in precarious and temporary jobs, will require new methods to engage and follow workers as they move from one work setting to another or experience periods of unemployment. This challenge is already the case in industries such as construction, where workers shift from one worksite to another and may experience differing risks across sites. These risks need to be examined as potentially additive or synergistic (Manjourides et al., 2018; Evanoff et al., 2020). These increasingly complex scenarios of work-related exposures have implications not only for exposures to physical job hazards but to organizational and psychosocial risks as well. In addition, given the importance of conducting studies of diverse workers with varying cultures, languages, documentation statuses, competing commitments, and literacy, researchers must take account of worker vulnerabilities and needs when designing studies and collecting data.

Effective stakeholder engagement can help ensure that samples of enterprises and workers are representative. Tailoring research questions to the priorities of employers and workers alike can increase the relevance of the research and provide an incentive for participation. Innovative approaches to engaging workers, through organized labor where available as well as other worker advocacy groups, as well as with participatory methods (Cherniack et al., 2019), will be critical to ensure that workers' priorities are identified.

4. Discussion

We have presented a conceptual model as a research framework for investigations that are relevant to the expected evolution of work. This systems-level model provides a structure for framing research hypotheses and questions across multiple levels of influence and supports a strategic approach to respond to evolving research needs (Leischow et al., 2008). This strategy offers a nimble structure for responding to rapid changes influencing the nature of work, such as those observed in the COVID-19 pandemic.

This model can also help in setting research priorities to ensure that research ultimately makes a difference in improving the conditions of work, thereby protecting and promoting worker safety, health and wellbeing. The systems approach embodied by this conceptual model acknowledges complexities and intersections across multiple levels of

influence on worker safety, health and wellbeing. This goal aligns with criteria for setting research priorities established by NIOSH focusing on evidence-based assessment of burden, need and impact (Felkner et al., 2019). In addition, the model provides cues for linking work-related health determinants with other life domains, while also guiding and informing policy and practice.

The research suggested by this conceptual framework will require collaborations across disciplines. In addition to relying on the knowledge foundation and research methods of public health and more specifically, traditional occupational safety and health, it will be necessary to bridge disciplinary boundaries across the fields of economics, sociology, psychology, organizational management, social work, public policy, industrial relations, law, and related fields, in order to grapple with changing social, economic and political landscapes and accompanying trends in employment work organization and design. These critically important systems-based approaches require a move toward transdisciplinary science, which aims to embed knowledge and expertise from individual disciplines within a common framework to create an integrated perspective that dissolves disciplinary boundaries (Choi and Pak, 2006; Stokols et al., 2008). The product of this approach will be creation of a robust evidence base to address the shared interest in evolving determinants of worker safety, health and wellbeing. To encourage this collaborative approach, those responsible for educating the next generation of researchers and practitioners will need to plan for training diverse investigators in a broad array of knowledge and skills needed to respond to emerging challenges and trends (Felkner et al., 2020). These include transdisciplinary research skills, communication skills for facilitating effective communication across disciplines and audiences, skills in team science and leadership to guide transdisciplinary teams, and skills for translating research findings to policy and practice (Schulte et al., 2019; Stokols et al., 2008).

This process will not be easy. Traditional research training and pathways for research funding, publication, and academic advancement continue to reward individual over team efforts and single disciplinary work over collaborative and transdisciplinary accomplishment. Nonetheless, there is growing recognition of the need to respond to complex public health challenges through transdisciplinary research. An important step in this process is development of conceptual models of complex systems that are understood and embraced by investigators with diverse disciplinary backgrounds.

4.1. Limitations

We have focused on the application of this conceptual model within the U.S. and other high-income countries. The changes described in economic, social, and political environments have parallel and significant implications for low- and middle-income countries. Exploration of specific contexts of the forces shaping work in low- and middle-income countries is beyond the scope of this paper, although we believe that research questions provoked by the model can be used to generate a wide range of hypotheses relevant elsewhere. The expanded conceptual model presented in Fig. 2 captures multiple layers of intersecting influences on worker safety, health and wellbeing, but is limited by the static nature of this representation. We recognize that these are dynamic, complex systems with multiple interactions between and within levels not captured in this representation. While any model is an oversimplification, we nonetheless believe this model is useful in understanding and addressing issues central to the health, safety, and wellbeing of working people worldwide. As is evident in the literature cited here, there has been an over-reliance on cross-sectional surveys and convenience samples. Future research will benefit from standardized measures applied systematically in diverse samples over time.

5. Conclusions

A systems-based conceptual model helps frame and motivate

research that may contribute to better understanding and solving problems as the workforce, employment relationships, workplaces, and technologies evolve. Predictions of how work will change vary considerably, and none of the multiple potential scenarios are inevitable. The emerging future may be influenced by an informed and empowered workforce, policy initiatives, and evidence-based options advanced by research and translated into practice. A research approach that anticipates and can adapt to trends in the way work is structured, managed, and experienced by workers can effectively inform such policies and practices. This research may also help to identify and address the potential for growing inequalities in the effects of work on the health, safety and wellbeing of workers.

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