



WORKtoZERO

an nsc program

Safety Technology 2024:

Examining Trends in Technology
Solutions Used to Reduce Serious
Injuries and Fatalities in the Workplace

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Executive Summary

The goal of the Work to Zero initiative at the National Safety Council (NSC) is to eliminate workplace fatalities through the use of technology. Work to Zero's initial research in 2020 identified the top hazardous situations and associated risks that contributed to workplace fatalities across various safety-sensitive industries, and then identified relevant environment, health and safety (EHS) technologies that could be used to address those hazards. Work to Zero surveyed employers and employees to understand their familiarity with those safety technology solutions. Employers were asked which technologies they perceived as applicable to the hazards in their workplace, which technologies they were considering, and which technologies were already being tested or used in their workplace. In 2023, three years after the initial survey, Work to Zero redeployed the survey to understand the changes and trends in safety technology implementation. This report summarizes the findings from the most recent survey with a particular focus on changes in the past three years.

Key Findings:

1. Both employers and employees reported an increased likelihood of exposure to all workplace risks included in the survey, with the most significant increases reported by employees.
2. Fatigue remains the most likely exposure across industries and was reported as a top contributor to injuries in the workplace. While workplace violence is considered the least likely exposure, concern over these incidents significantly increased between survey waves.
3. Across all surveyed technologies, employers reported increased technology applicability and consideration (i.e., more employers perceive these solutions to be relevant to the hazards in their workplaces, and more are considering implementation). Additionally, 83% of employees agreed they were open to trying and using new safety technologies in the workplace.
4. The most notable increases in usage were for risk management software, proximity sensors and drones, while use of other technologies has remained relatively similar between waves.
5. Purchase cost remains a key barrier in adopting safety technologies for employers, although there is a marked decrease since 2020. Concern over data collection and privacy issues are also top concerns for employers. Perceptions of current technologies and whether they are meeting organizational needs are both a key barrier and key driver to the adoption of new safety technologies in the workplace.

Introduction and Background

Fatal injury statistics and trends

The Bureau of Labor Statistics (BLS) reported 5,486 fatal work injuries in the United States in 2022, which equates to a worker dying every 96 minutes (BLS, 2023). Fatality statistics for 2022 represent a 5.7% increase from the 5,190 fatal occupational injuries that occurred in 2021, and a 2.9% increase from pre-pandemic levels in 2019 (BLS, 2024).

There were 1,620 fatalities in transportation and material moving occupations, which was an increase of 6.4% since 2021. The group with the second most fatal injuries were workers in construction and extraction occupations. BLS reported the fatality rate for this group increased from 12.3 to 13.0 deaths per 100,000 full-time employees (FTE) in the past year. Within this group, most fatal injuries occurred from slips, trips or falls, and overall, falls increased 1.8% in the past year. Transportation incidents remained the top cause of fatal occupational injuries (37.7%). There were notable increases (8.9%) in homicides in the past year, as well as fatalities due to exposure to temperature extremes (18.6%) (BLS, 2023).

Work to Zero

In 2019 NSC launched its Work to Zero initiative, supported by a grant from the McElhattan Foundation. The goal of the Work to Zero initiative is to eliminate workplace fatality risk through technology implementation. To do this, Work to Zero researches technology solutions and ways to integrate them into the workplace, provides educational resources to increase workplace adoption, and fosters key partnerships with stakeholders in the field. With this approach, Work to Zero strives to help employers adopt promising technology innovations geared toward eliminating workplace fatality risks within our lifetime.

In 2020, the Work to Zero initiative released its first whitepaper, [*Safety Technology 2020: Mapping Technology Solutions for Reducing Serious Injuries and Fatalities in the Workplace*](#). For that paper, NSC researchers reviewed data from the Census of Fatal Occupational Injuries (CFOI) and used BLS characteristic types (e.g., worker activity, event or exposure, primary or secondary source) to contextualize workplace fatalities within hazardous situations rather than looking at fatalities by industry or by event or exposure, which is more typically depicted in statistical representations. This method was employed to focus on situations that apply across industries (e.g., working at height) and identify workplace risks with the greatest potential for serious injuries and fatalities. NSC categorized the workplace fatalities into one of 18 different hazardous situations, relevant across industries and worker activities (e.g., work at height, machinery operation, confined space entry) (Washburn, 2020).

To supplement the BLS CFOI data, NSC researchers also interviewed 32 EHS professionals representing different industries including, but not limited to, construction, oil and gas, utilities, manufacturing, and mining. These professionals were asked to provide the top hazardous situations and associated risks within their facilities. Thus, NSC also identified the inherent situational risks (e.g., fall to lower level, struck by machinery) and the systemic contributing factors (e.g., lack of training, fatigue) that can exacerbate risk within those hazardous situations.



NSC then partnered with Verdantix, a research and advisory firm with research coverage dedicated to EHS technologies and innovation, to identify more than 100 relevant EHS technologies helpful in mitigating these situational and systemic risks. These technologies were grouped into 11 categories: analytics, content, data management, equipment, exoskeletons, mobile apps, personal protective equipment (PPE), robotics, sensors/detectors, software and wearables. The 2020 report then mapped these technology solutions to each of the 18 hazardous situations and included information on how effective EHS professionals perceived them to be at addressing those risks (Washburn, 2020). Technologies perceived as most effective and of interest to interviewees were selected to be examined furthered:

- **Aggressive behavior detection:** technology to identify aggressive behavior such as computer vision enhancement, artificial intelligence and monitoring employee working behavior
- **Drones:** autonomous aerial vehicles used for work at heights or in confined spaces
- **Extended reality:** virtual or augmented reality for training purposes or to enhance natural environments
- **Location geofencing:** technology that warns employees when they enter specified geofenced sites, which may be hazardous or restricted
- **Predictive analytics/AI:** predictive analytics, artificial intelligence (AI) or machine learning technologies for analyzing safety issues to make predictions about the future
- **Proximity sensors:** technology to detect impending collisions
- **Real-time location tracking:** technology to monitor lone workers with either real-time location tracking and/or communication between the worker and emergency response teams or management directly
- **Risk management software:** technologies to assist in acceptance, mitigation or avoidance of operational risk
- **Robotics:** autonomous mobile robots, automated guided vehicles, and robotic arms for assembly or manufacturing
- **Wearable gas sensors:** technologies to detect hazardous gas and/or environments with digital connectedness and real-time monitoring
- **Wearables to track worker health:** technology to track workers' health risks such as heart rate, heat stress or fatigue
- **Worker impairment detection:** technologies to detect multiple causes of worker impairment such as substance use, fatigue, stress, mental health conditions or other chronic medical conditions
- **Workzone intrusion detection:** technologies that use alarms or alerts to signal workers when unwanted pedestrians or employees have entered potentially dangerous areas of the worksite

One of the next projects undertaken by Work to Zero in 2020 was a survey of employers and employees in high-risk industries. The goal of the survey was to understand the awareness, attitudes and usage of safety technologies within different industries. Using the top hazardous situations, risks and priority technologies identified in the 2020 white paper, this survey was used to collect data on employer and employee top concerns, most likely exposures in the workplace and the top contributors to injuries. The survey was redeployed in 2023. **The objective of this current work is to examine trends in workplace hazards and safety technology implementation since 2020.**

Research Approach

The methodology for this project consisted of two main parts: a survey and the formation of a working group comprised of industry professionals and subject matter experts.

In 2023, researchers re-deployed the 2020 survey to identify:

1. Workplace hazards employers and employees perceive as likely exposures and contributors to occupational injuries
2. Safety technology solutions currently being used to address workplace hazards
3. Barriers and motivators to implementing safety technology
4. Changes and trends since the 2020 survey

Both the 2020 (Wave 1) and 2023 (Wave 2) surveys were deployed online among employers (n=500) and employees (n=1000). Data collection occurred during April 2020 (Wave 1) and August and September 2023 (Wave 2). Minimal revisions were made to the survey between waves to ensure valid comparisons. Revisions to Wave 2 included the addition of new risks (i.e., thermal stress), concerns (i.e., data privacy) and technologies (i.e., location geofencing, lone worker monitoring) identified by Work to Zero as emerging priorities during the previous three years.

Additionally, a dedicated workgroup comprised of safety professionals, researchers and solution providers was formed to gather insight and feedback from subject matter experts during the research process. The workgroup also served as reviewers for the report to ensure accuracy and relevance.

Survey Results and Discussion

Demographic data for both employers and employees were collected and compared to ensure similar samples between waves. For employers, there were no significant differences between waves for job role, industry, region and decision-making responsibility. There were significantly less employers from the smallest organizations (<50 employees) (2% vs 7%) and significantly more employers from organizations with 250 to 499 employees (19% vs 12%) in Wave 2. For employees, there were no significant differences between waves for job role, ethnicity, gender, region and company size. There were significant increases in employees working in manufacturing (29% compared to 25%) and retail (20% compared to 13%), as well as significant decreases in employees working in utilities (7% compared to 11%) and agriculture (6% compared to 10%) in Wave 2.

Likely Exposures

Employees were asked how likely they are to be exposed to different hazardous situations in their jobs. Similarly, employers were asked how likely their employees would be exposed to those situations. Since 2020, respondents reported increased likelihood of exposure to all the situations included in the survey (Table 1). During discussion with the workgroup on the perceptions of likely exposures, members pointed out potential possibilities for the across-the-board increases including impacts from the COVID-19 pandemic. Due to the deployment of Wave 1 during the start of the pandemic, it is possible that since April 2020 the pace of work may have changed so people feel like they are more exposed, or perhaps there are less people to do the same amount of work. Another possibility is that the way work is performed has changed slightly with the pandemic. As more people work remotely and more work becomes automated, manual tasks may be perceived as riskier.

The increases in employees reporting likely exposures were significant for most risks and were more similar to employer responses than in Wave 1. The most notable differences between employer and employee perceptions were related to lack of workplace awareness and work at heights, both of which employers perceived as more likely exposures than employees. Workplace violence is still perceived as the lowest exposure risk for both groups. However, the perceived likelihood of exposure to workplace violence has significantly increased since 2020, with at least one-third of both employees and employers considering it a likely exposure.

Table 2. Percent of respondents reporting likely exposures to fatigue compared by industry

	Manufacturing	Retail	Construction	Transportation & Warehousing	Utilities	Agriculture	Mining / Quarrying
Employee	77	83	84	82	77	89	74
Employer	76	81	78	77	74	74	*

*There were not enough respondents for employers in Mining/Quarrying to include in the analysis

Contributors to Injuries

Survey respondents were also asked which risks caused or contributed to a serious injury in their workplace. Fatigue was the top contributor to injuries reported by both employees and employers (Table 3). Overall, employers' and employees' responses regarding injuries were similar.

Table 3. Percent of respondents reporting risks as having caused or contributed to a serious injury in their workplace

Risk	Employees	Employers
Fatigue	44	46
Lack of Proper Training	42	38
Lack of Workplace Awareness	41	42
Heavy Equipment Operation	36	32
Thermal Stress	36	32
Work at Heights	30	31
Repair & Maintenance	28	27
Construction & Installation	27	23
Confined Space Entry	15	13
Permit to Work Failure	14	12
Workplace Violence	12	13
None of the above	10	11



Figure 1 illustrates the responses regarding both the perceived likelihood of employee exposure to these risks, as well as which risks contributed to workplace injuries. Employee responses are shown in green circles and employer responses are shown in white circles. The figure illustrates that both employers and employees perceived likely exposures consistently (i.e., similar alignment along the y-axis). Employees did, however, report higher contributions to injuries than employers for several risks (i.e., lack of proper training, lack of workplace awareness, heavy equipment operation, thermal stress, repair and maintenance, construction and installation, confined space entry, permit to work failure).

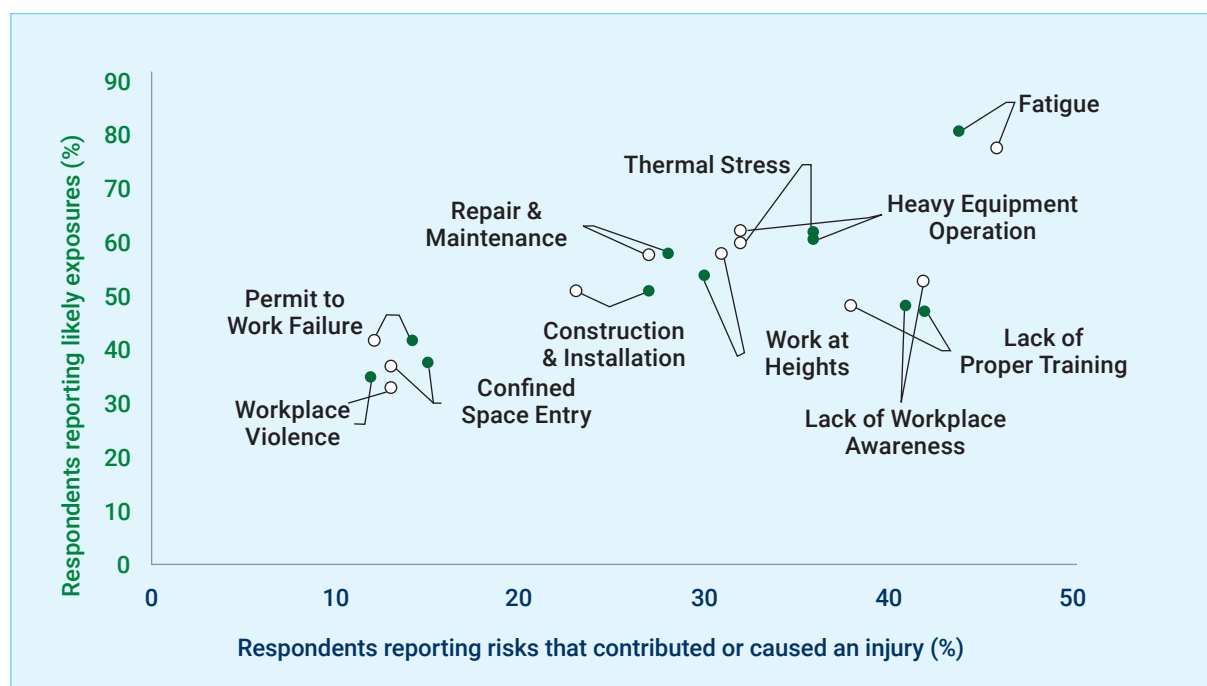


Figure 1. Comparison of employee (green circles) and employer (white circles) responses regarding both the likelihood of employee exposure and contributors to injuries

Comparing responses by perceived exposure likelihood and known contributors to injuries may offer insight into how to address these risks. Risks in the top right quadrant of Figure 1 may need to be prioritized in the workplace as both employers and employees indicate they are likely exposures and top contributors to injuries. Addressing these risks may be most impactful in overall injury reduction, however, it is important to note this particular comparison does not take into account the severity of these risks so all risks should still be monitored and managed in the workplace.

Responses that fall towards the top left area in the figure (i.e., permit to work failure) may indicate risks that are being controlled more effectively than those on the right, as their placement indicates more frequent exposures but less resulting injuries. Conversely, responses in the bottom right area of the figure (i.e., lack of training, lack of workplace awareness) suggest that even if they are unlikely exposures, these risks may be more likely to lead to injuries when workers are exposed.

Another possibility regarding the position of lack of training and lack of workplace awareness is that there is bias present in respondents' perceptions of these risks. Both risks fall more toward the lower right quadrant, but exposures may be more likely than reported. Additional survey responses indicate there may be bias present in training perceptions as there was a significant discrepancy between employees' responses regarding themselves and their coworkers. For instance, 21% of employees reported they occasionally or frequently did not use safety equipment properly. However, a significantly higher amount (56%) reported they occasionally or frequently observed their coworkers not using safety equipment properly. This trend was similar to responses from the Wave 1 survey (22% and 47%). This finding reinforces the need for continued safety training and regular reviews of work processes and job sites to understand how work is done.

Many organizations lack a systemic approach to evaluate safety training programs and their impact on safety attitudes, behavioral changes and safety culture. For more information on the key considerations involved in developing an effective safety training program, check out the Campbell Institute's [A Foundation for Safety Training Effectiveness](#) (Carlsen, 2023).

Employer Concerns

Employers also were asked about their level of concern (not a concern, minor concern, major concern) about different hazards (e.g., fatigue, workplace violence) and issues (e.g., aging of the workforce, technology automation) in the workplace (Table 4).

Table 4. Percent of employers who reported minor or major concerns with the following workplace issues

Concern	Wave 1	Wave 2
Worker wellbeing (e.g., mental, physical and/or emotional health)	92	92
Non-life-threatening employee injury on the job such as sprains or strains	85	87
Fatigue in the workplace	85	86
Lack of worker compliance with proper safety procedures	83	85
Serious employee injury on the job	81	83
Employee illnesses (e.g., influenza, COVID-19)	95	82
Lack of proper training or supervision	76	80
Data privacy	*	80
Substance use in the workplace	*	79
Workplace fatality	71	72
Failure of leadership to promote safety across the organization	71	72
Aging of the workforce	71	70
Technology automation causing job loss and/or the need to retrain employees	*	67
Incidents of workplace violence	57	66

*Not included in Wave 1 survey
Numbers in **bold** represent significant ($p < 0.05$) differences

A significant decrease in concern over employee illness was reported in the Wave 2 survey. Since Wave 1 was deployed in April of 2020, it is likely those responses were influenced heavily by the start of the COVID-19 pandemic.

Even though approximately 10% of employers and employees indicated their organization experienced an incident of workplace violence that contributed to an injury, both groups' perceived likelihood of exposure and concern over workplace violence increased between waves. Sixty-seven percent of employers believed workplace violence was either a very unlikely (14%) or unlikely (53%) exposure but 66% were still concerned for the risk, which was a significant increase from Wave 1 (Table 4). This change may be impacted by several factors. First, workplace violence trends have increased since 2020, up nearly 23% in 2021 and 34% in 2023 (BLS, 2023). This change also may have been impacted by the pandemic, attributed both to an increase in worker experiences with anger and harassment, as well as the increased media attention given to these events.

Across industries, there were no significant differences in the concerns reported, but employers in the **Construction** industry reported notably higher concern of workplace fatalities (81%) than other industry responses (61% to 76%). This may be due to the higher number of likely exposures to workplace risks and the continually high fatality rates in this occupational group. **Transportation and Warehousing** employers reported notably higher concern for employee illness (94%), data privacy (89%) and workplace violence (74%). **Agriculture** reported higher concerns for lack of proper training (85%) and substance use (87%) than other industries, while retail employers were most concerned with fatigue (92%), lack of training (85%) and technology automation (72%).

Trends in Technology Applicability, Consideration, Testing and Use

Survey participants were asked to identify technologies that they believed were relevant to their organizations (applicable), that they were considering using, and that they were testing or using. Figure 2 illustrates the gaps in the technology landscape between applicable technologies, consideration by organization and actual implementation of technology.

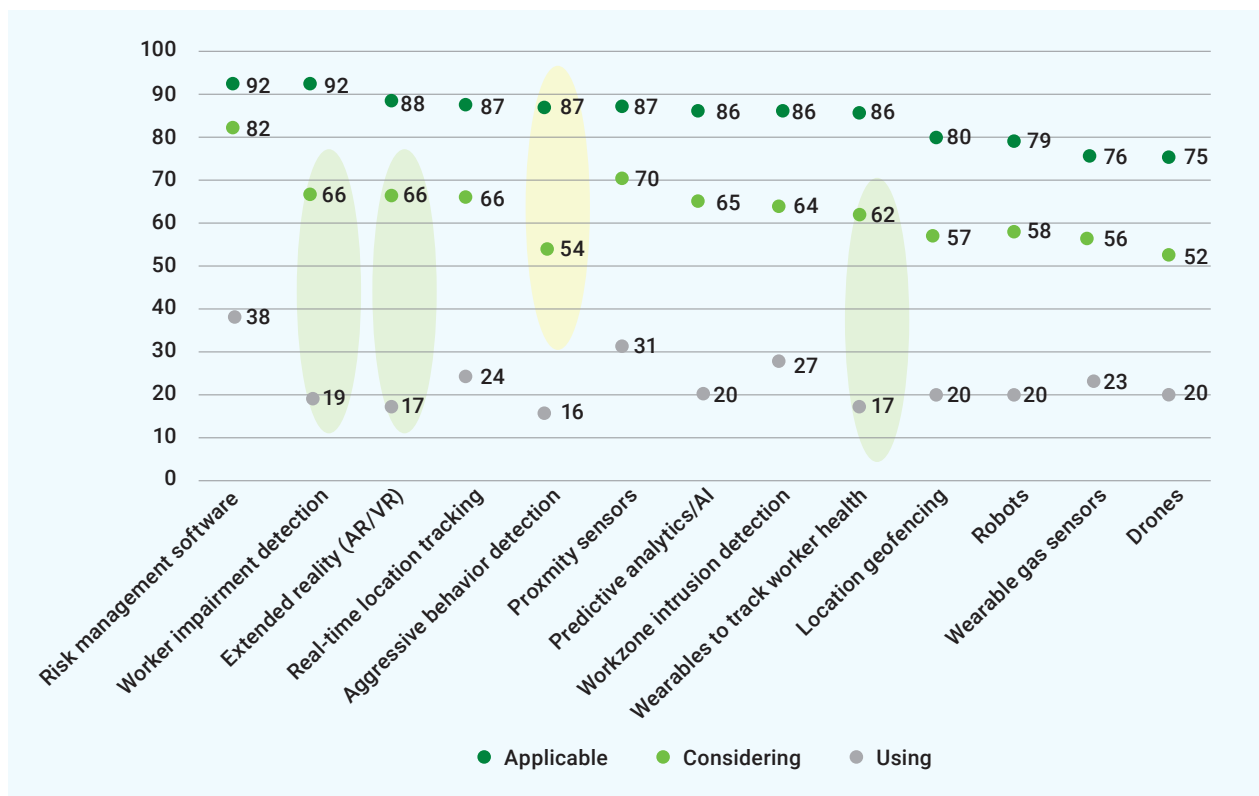


Figure 2. Technology Landscape illustrating percentage of employers' responses regarding applicability, consideration and use. The largest gaps between stages are highlighted.

The following three tables compare employers' responses between survey waves regarding applicability, consideration and usage for different technologies. For all technologies, the percent of employers who believed the technologies to be applicable to their workplace hazards increased (Table 5). Increased consideration of all technologies also was reported (Table 6). More employers perceive these technology solutions to be relevant to the hazards in their workplaces and more are considering implementation.

Table 5. Percent of employers who believe the technology is applicable to their organization

Safety Technology	Wave 1	Wave 2
Risk management software	90	92
Worker impairment detection	90	92
Extended reality (AR/VR)	83	88
Aggressive behavior detection	83	87
Proximity sensors	84	87
Predictive analytics/AI	83	86
Wearables to track worker health	83	86
Robots	67	79
Wearable gas sensors	70	76
Drones	68	75

Table 6. Percent of employers who reported they were considering safety technology implementation

Safety Technology	Wave 1	Wave 2
Risk management software	73	82
Worker impairment detection	62	66
Extended reality (AR/VR)	60	66
Aggressive behavior detection	49	54
Proximity sensors	63	70
Predictive analytics/AI	61	65
Wearables to track worker health	57	62
Robots	50	58
Wearable gas sensors	52	56
Drones	46	52



For technology use, however, there is not an overall trend. Use of certain technologies such as risk management software, proximity sensors and drones has increased since 2020, while use of other technologies has remained relatively stagnant (Table 7). As the first steps in implementation are determining applicability and consideration, these data suggest there may be increased usage in the next few years.

Table 7. Percent of employers who reported using safety technology

Safety Technology	Wave 1	Wave 2
Risk management software	32	38
Worker impairment detection	19	19
Extended reality (AR/VR)	18	17
Aggressive behavior detection	14	16
Proximity sensors	27	31
Predictive analytics/AI	21	20
Wearables to track worker health	18	17
Robots	20	20
Wearable gas sensors	23	23
Drones	15	20

Across industries, 65% of employers reported their organizations had recently researched or considered the adoption of new safety technologies. Consideration in the construction industry (84%) was significantly higher than other industries (57- 72%).

Twenty-three percent of employers, compared to 26% in Wave 1, reported not being interested in or ready to adopt safety technology. This group identified the need for more information and resources. The percentage of employers considering themselves later adopters has remained relatively similar between waves (54% in Wave 1 compared to 55% in Wave 2). Later adopters described themselves as being willing to adopt new technologies after they have been on the market for some time and demonstrated evidence of effectiveness in the field.

Twenty-three percent of employers, a 5% increase from Wave 1, consider themselves to be early adopters of safety technology and are piloting or using technology in the workplace. The Construction industry reported a significantly higher average number of technologies tested or used (5.7) compared to other industries. Averages for the other industries were 4.4 for Manufacturing, 4.2 for Utilities, 4.1 for Transportation and Warehousing, 3.8 for Retail, 3.6 for Agriculture, and 2.9 for Mining and Quarrying.



Employers who reported using various technologies were asked how long ago they had been using them (i.e., don't know, more than 2 years ago, 1-2 years ago, 6-12 months ago, within the past 6 months). Responses indicate that predictive analytics, aggressive behavior identification tools and wearable vital signs monitors were the top three most implemented safety technologies over the past year (Figure 3). Drones also were reported as one of the top implemented technologies within the past 6 months. In 2020, extended reality and wearable gas sensors had significantly higher implementation within the past year.

One of the most notable jumps in use within the past two years was for predictive analytics and artificial intelligence (AI). Of the employers currently using this technology, 85% reported implementation within in the past two years. As the interest in AI increases and the technology becomes more accessible, more work needs to be done to understand the specific use cases and the different ways AI is utilized in various technologies.

Further research clarifying the timing of testing, piloting and adoption phases of technology use may increase understanding of these trends in terms of technology maturity and also may be of benefit to help understand the drivers and barriers of adoption.

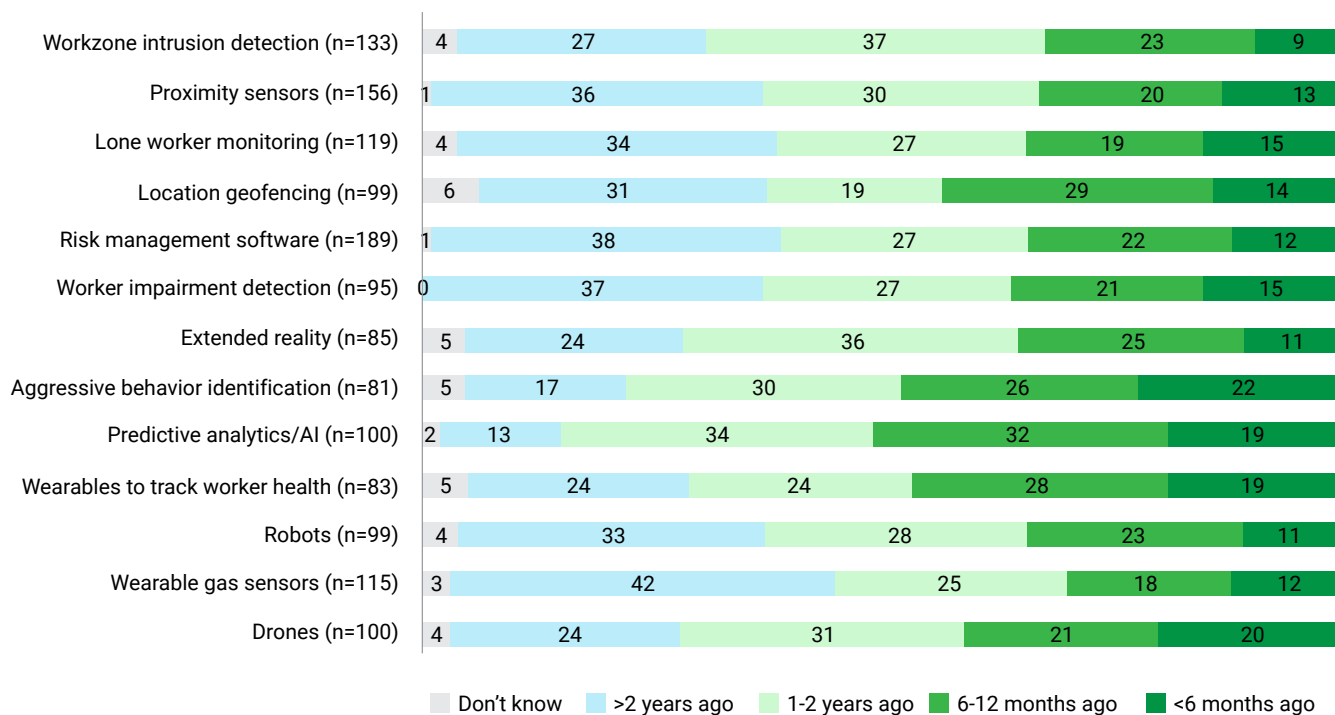


Figure 3. Percent of employers currently using technology solutions reporting recency of implementation

Employees are significantly more aware of emerging safety technologies compared to 2020 survey data. In Wave 2, 31% of employees reported being very familiar with a range of safety technologies compared to only 20% in Wave 1. Conversely, the number of employees reporting no knowledge of safety technologies (19%) in 2023 was significantly lower than in 2020 (27%). Workgroup members discussed their experiences with this firsthand and noted there is increased use of technology in our personal lives (e.g., extended reality, drones, vital signs monitors), and many employees are open, and even eager, to use these solutions at work. This observation was supported by survey responses indicating that 49% of employees strongly agreed and an additional 34% (83% total) agreed they were open to trying and using new safety technologies in the workplace.

Table 8. Percent of employees reporting consideration, testing or use of different safety technologies

Technology	Employees	
	Wave 1	Wave 2
Proximity sensors	34	48
Impairment detection	29	36
Extended reality (AR/VR)	27	34
Predictive analytics/AI	*	35
Wearable vital signs monitoring	26	36
Robots	24	35
Wearable gas sensors	31	35
Aggressive behavior detection	21	30
Drones	20	26

*Not included in Wave 1 survey
Numbers in **bold** represent significant ($p < 0.05$) differences

Employee survey responses indicate that across industries, consideration, testing and use of safety technology solutions have all increased since 2020 (Table 8). Employee responses indicate those in the construction industry are more likely to test or use new technologies, especially proximity sensors, workzone intrusion detection, wearable gas sensors, drones and location tracking, than other industries. Manufacturing employees were more likely to test or use robots.



Barriers to Adoption

To increase technology implementation, it is critical to understand the barriers to adoption that are driving the gaps between the three phases (applicability, consideration, use) illustrated in Figure 2. The gap between applicability and consideration can be described as a knowledge and strategy barrier. To close this gap, employers may need resources to help them understand how specific technologies may benefit their organizations and resources to assess their readiness for implementation. When considering technology implementation, employers must think about how technology may align with their business values, how the technology may impact stakeholders, identify necessary support and anticipate errors (Lin, Guasta & Whitcomb, 2021).

The gap between consideration and use can be described as an uptake or implementation barrier. If employers believe a technology is relevant to their workplace hazards and they are considering it, then it is critical to understand the reasons they are not moving forward with adoption. The survey was designed to collect responses identifying barriers to technology adoption. These responses may help explain the implementation barrier.

Purchase cost remains a key barrier in adopting safety technologies for employers, although there is a marked decrease since 2020 (Figure 4). There also was a significant decrease in reporting that management would be unlikely to approve the purchase of new safety technology since 2020 for both employers (41% compared to 51%) and employees (38% compared to 47%). Cost may decrease as technologies stay on the market for longer but understanding overall return on investment (ROI) also may help employers see purchase cost of technologies as less of a barrier. The price of injuries is high and “business as usual” may cost more. For more information, see the Work to Zero report [Making the Business Case for Safety Innovation](#) (NSC, 2022).

Employers also reported several other barriers to implementation, including concerns over collecting personal information that may violate employee privacy (49%). Interestingly, there was a significantly lower number of employees who reported this same concern (40%). Employers also were more likely to report a lack of priority regarding safety technology adoption. Forty-eight percent of employers reported current safety equipment meets their needs and 46% reported new technologies are not considered a priority in their workplace. Another barrier of note for 41% of employers was the concern that safety technologies have not been tested or proven in the workplace.

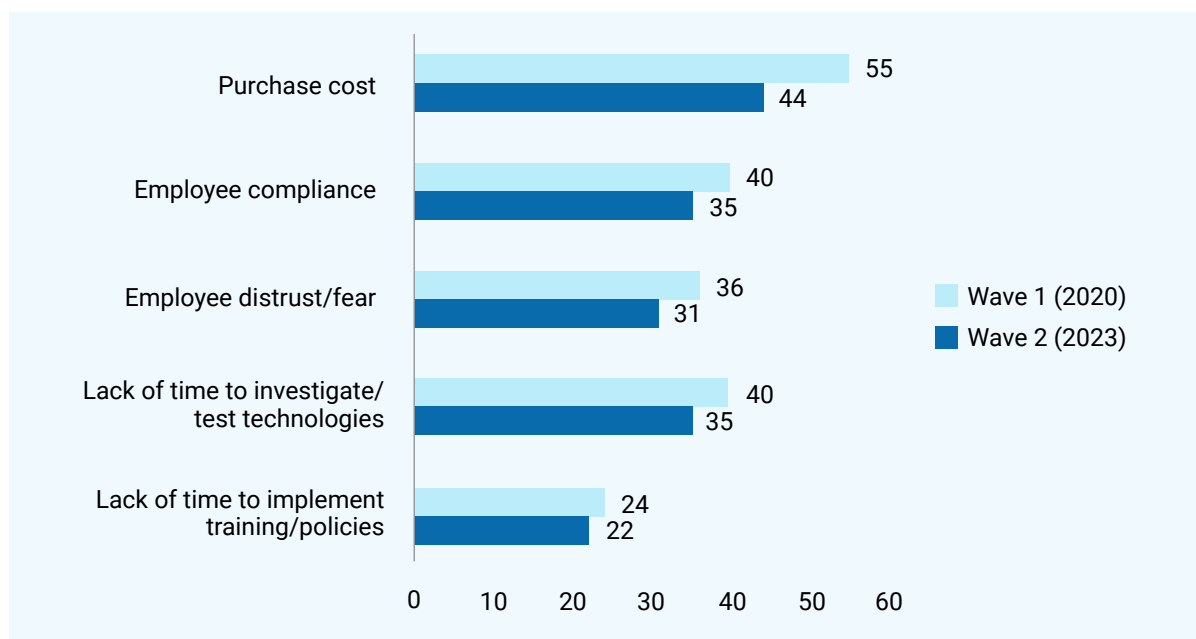


Figure 4. Percent of responses regarding barriers to technology adoption

Despite employees' general willingness and openness to trying new technologies, 46% reported they did not want to change the safety equipment they were currently using and 41% reported current safety equipment and technology meets their needs so there is no need for new adoption. Conversely, some of the top drivers for technology adoption identified in survey responses were if current technology and equipment were no longer meeting their needs. Approximately one-third of employers and employees considered this to be one of the main drivers for exploring technology solutions. The most significant driver of technology implementation for both employers (40%) and employees (42%) was if an employee is seriously injured on the job.

Employees also were surveyed about barriers to using more traditional safety equipment and PPE as well as safety technologies. The main obstacle for using PPE in the workplace was comfort (42%) (Table 9). Many of these barriers may translate to barriers for safety technology as well, especially for any wearable technologies such as vital signs monitors, lone worker monitoring devices, extended reality devices or exoskeletons.

Table 9. Percent of employees reporting barriers to using PPE in the workplace

Barrier	%
Comfort	42
Equipment interferes with work	28
Obstructs vision or movement	27
Fit	26
Aging equipment	26
Lack of training	26
Supply/Availability	25
Ease of use	23
Time needed to properly don PPE	23

In 2022, Work to Zero published a [Pilot and Implementation Roadmap](#) (Guasta, Lin, & Whitcomb) to create a guidance framework for employers adopting safety technology. The Roadmap sets out specific actions in four stages to help address these barriers to adoption and maintain a human-centered approach to technology implementation. As companies prepare to implement technology, it is critical to engage workers from the beginning of the process to gain insight on potential impacts of technology and to gather feedback from end users on their experience using it. Gathering feedback on workers' experiences using and wearing technology is critical in understanding how successful full-scale implementation may be.

Conclusions and Future Directions

Since the deployment of the first survey, there has been a substantial increase in concern and perceived exposure for a wide variety of workplace hazards. Across industries, fatigue continues to be the most likely exposure and top contributor to workplace injuries. BLS data indicates workplace fatalities also have been increasing in the last three years and it is critical we find ways to control occupational risks and protect workers.

Technology will inevitably play a critical role in the future of workplace safety. Safety technology solutions provide opportunities to keep workers safe from the most dangerous tasks, to reduce their workloads, and to mitigate adverse outcomes through monitoring and alert systems. Verdantix researchers describe ways safety technology can be used at each level in the Hierarchy of Controls: eliminating hazards through automation, substituting inadequate equipment with innovative solutions, engineering processes to protect workers, innovating training to increase efficacy and ensuring proper use of PPE (Goldstein & Pennington, 2023).

To take advantage of these opportunities, workplaces must find ways to overcome barriers to adoption and successfully implement technology (e.g., purchase cost, data privacy concerns). Thus, more research needs to be done to understand how to address the implementation barrier (i.e., the gap between considering and using technology). More research is needed to understand how levels of technology maturity may factor into implementation decisions. More than half of the employers surveyed reported they would be more willing to adopt technology after it had been on the market for a longer period of time and would be able to see evidence of effective implementation in other workplaces. Sharing informative resources and case studies of successful technology adoption will likely help motivate this group to innovate.

NSC plans to continue this work by researching new technologies and best practices for a human-centered approach to technology implementation. The Council will continue to engage with early adopters to share impacts and lessons learned from their experiences with technology in the workplace. NSC will continue to focus on creating resources for small- and medium-sized companies to help make innovation accessible for all employers. To learn more about Work to Zero, how to get involved and how to support this effort, please visit nsc.org/worktozero.

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Author: Kate Crawford

Additional Staff: Kenna Carlsen, Sarah Ischer, Kadie McCorry, Emily Whitcomb



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