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PRACTITIONER REPORT

Alert at Work? Perceptions of Alertness Testing and Recommendations for Practitioners

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Abstract

Around-the-clock, 24/7 operations are common in many industries, yet contribute to employee fatigue, which can have grave consequences for worker safety, public health, and the environment. Alertness testing is one option for identifying and mitigating issues related to fatigue at work. We review alertness testing options, including fatigue risk management systems and app-based tools, and share results from a study evaluating employee and manager perceptions of alertness testing. Despite a growing body of research on the validity of app-based alertness tests, it is also critical to understand how these tools are perceived by workers and management. To investigate perceptions of alertness testing, mixed-method data were collected from organizations across four safety-sensitive industries (i.e., a mining company, fire department, and two construction companies) that were in the process of implementing an alertness testing platform. Results suggest that employees and managers are open to and optimistic about implementing new alertness testing safety tools. Employees in work environments with strong managerial support for safety were particularly open-minded to alertness testing at work. However, some employees and managers expressed reluctance towards alertness tests. We provide recommendations for how occupational health and safety professionals can effectively select alertness tests and implement alertness testing. Ethical considerations related to identifying whether workplace alertness testing is needed, and how to protect employees and their data, are discussed.

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Workplaces are increasingly relying on around-the-clock operations to meet society's demands for production, efficiency, public health, and safety. Non-standard working hours (e.g., night shifts), rotating schedules, and long shifts are common in industries like construction, manufacturing, transportation, healthcare, and public safety, creating major challenges for employees who are required to work safely and productively despite these schedules. Alertness, or the state of being aware and attentive to one's surroundings, is impaired in 24/7 operations (Rosekind, 2005b), and researchers have suggested that society, companies, and employees themselves underestimate the costs and consequences of diminished alertness in the workplace (e.g., Barnes & Drake, 2015; Rosekind, 2005a).

Fatigue is characterized by diminished alertness, and has critical implications for safety incidents, injuries, and performance (Lerman et al., 2012). In 2020 alone, over 2.5 million nonfatal workplace injuries and illnesses and nearly 5,000 fatal work injuries were reported by private industry employers (U.S. Bureau of Labor Statistics, 2020). Yet, hidden within these estimates is the role of fatigue, which amplifies risk for safety incidents and injuries. For example, overtime schedules have been associated with injury rates 61% higher than standard working hours, while shifts 12-hours or longer have been associated with a 37% increased injury rate (Dembe et al., 2005). Fatigue has also been identified as a key factor in major incidents, such as the Three Mile Island and Chernobyl nuclear reactor meltdowns, the Challenger Space Shuttle disaster, and the Exxon-Valdez oil spill (Walsh et al., 2011), compromising worker safety, public health, and the environment.

Employee alertness testing is one promising strategy for managing diminished alertness and promoting workplace safety (e.g., Dinges, 1995). Alertness testing requires employees to complete brief reaction time tests (e.g., identifying unique shapes or symbols) on smartphones or computers at the start of their shift and/or at critical periods during their shift, such as after breaks or before beginning new tasks. Alertness scores are determined based on performance compared to the worker's personal baseline (e.g., an employee may take 10 alertness tests to establish a baseline level of alertness, and subsequent alertness tests are compared to their rolling baseline) and can be shared with management overseeing safety operations. Yet, much of what we know about alertness testing has evolved from work by scientists for research purposes, rather than applied practical purposes. Thus, "on the ground" occupational health and safety (OHS) professionals have few accessible evidence-based resources for understanding alertness testing, its advantages and challenges, and how to implement it ethically and effectively within actual workplaces. Additionally, employees and managers may be hesitant about implementing alertness testing tools, in light of broader controversies surrounding employee monitoring, surveillance, and privacy (e.g., Filabi & Hurley, 2019; Loo, 2021; Martin & Freeman, 2003; Society for Human Resource Management, 2019). Thus, the primary aims of this practitioner report are to review alertness testing, share data related to impressions of a new alertness testing platform in safety-sensitive industries (i.e., those that are particularly hazardous to the physical safety of employees and others around them), and provide recommendations for practitioners who are considering implementing alertness testing.

Alertness Testing to Identify Employee Fatigue

Efforts to prevent fatigue and promote safety at the national and industry levels in the U.S. typically include hours-of-service regulations (i.e., limits on working hours, minimum number of breaks, length of breaks), though these regulations have been criticized as being outdated and insufficient for monitoring worker alertness and safety (e.g., Gander et al., 2017; Rosekind, 2005a, 2005b). Fatigue results from a complexity of factors, including but not limited to sleep deprivation (i.e., obtaining no sleep over a 24-hour period), chronic sleep restriction (i.e., regularly obtaining less than the recommended seven hours of sleep per night), time of day (i.e., circadian phase), disruption to normal circadian rhythms, time spent awake, health factors (e.g., sleep disorders, chronic illness, mental illness, medications), environmental factors (e.g., light, noise), and workload (Lerman et al., 2012). The multitude of factors related to worker fatigue are not fully addressed by "one-size-fits-all" hours-of-service regulations. As a result, fatigue researchers have called on practitioners to adopt fatigue risk management systems (FRMSs), which are evidence-based approaches to managing fatigue and promoting alertness at work (Lerman et al., 2012).

FRMSs use ongoing data collection in the workplace to identify when employees experience excessive fatigue, mitigate the fatigue and associated risk factors, and continuously enhance workplace practices that promote alertness to improve employee safety and productivity (Gander et al., 2017; Retzer et al., 2021; Sprajcer et al., 2022). Alertness testing is a core component of FRMS as data collected from alertness testing is used to determine when and why fatigue is occurring, and in turn, develop additional solutions to mitigate fatigue risk. Although beyond the scope of this paper, these solutions may include a variety of efforts, such as new shift schedules, appropriate use of fatigue countermeasures (e.g., caffeine, naps), or training leaders to be more supportive of employee sleep (Dinges, 1995; Gander et al., 2017; Gunia et al., 2015).

Effectiveness of Alertness Testing

Alertness testing's utility is two-fold: first, it communicates to employees and managers that alertness is a key factor for preventing workplace accidents and injuries, and second, it allows the practitioner to identify shifts, times of day, or workgroups where additional programs or countermeasures are needed to combat fatigue.

The gold standard for assessing alertness is the well-validated psychomotor vigilance task (PVT), which measures reaction time when responding to visual stimuli (e.g., responding to the appearance of a red dot against a black background) (Dinges & Powell, 1985). The PVT typically takes up to 10 minutes to complete and is traditionally administered on computers in research laboratories, making it impractical to use in applied workplace settings. Consequently, researchers have developed shorter, three-minute versions of the PVT that can be used on computer and smartphone devices (e.g., Grant et al., 2017). Recently, there has been a growing body of research on commercially available smartphone applications (apps) for alertness

testing (e.g., 2B-Alert, Sleep-2-Peak, AlertMeter®), which have initial validity evidence suggesting they are comparable to the PVT in detecting alertness in sleep-deprived individuals (Brunet et al., 2017; Langley et al., 2009; Reifman et al., 2016, 2018). Alternative types of alertness testing have been used in safety-sensitive working populations, as well. For example, pupillographic sleepiness tests, which measure eye and pupil movements and diameter, have been used to assess sleepiness in truck drivers (Peters et al., 2014). Others have used performance on app-based math quizzes to measure alertness in nurses (e.g., Joo et al., 2015).

Methods for Evaluating Employee and Manager Perceptions of Alertness Testing

We assessed employee and manager perceptions, concerns, and openness to the implementation of a new alertness test in their workplaces, as the extent to which employees and managers within safety-sensitive industries are open to alertness testing has not yet been evaluated. User perceptions of new safety tools are important for ensuring success of program implementation and are likely of interest to practitioners considering alertness testing. For instance, if alertness testing is perceived unfavorably by employees or management, it will not be widely adopted and its potential benefits to workplace safety may not be realized.

Procedure

Employees and managers across four safety-sensitive work sites who were implementing the same app-based alertness test were recruited for the study. The AlertMeter®, developed by Predictive Safety SRP, Inc., assesses reaction time and decision-making accuracy based on a task to identify the orientation of shapes of varying difficulty. The test requires hand-eye coordination during an approximate one-minute duration. AlertMeter® has garnered initial validity evidence suggesting that the test can accurately detect cognitive impairment due to fatigue in sleep-deprived individuals (Langley et al., 2009; Sherry & Owen, 2021).

Participating work sites were recruited in conjunction with an existing trial period of the Predictive Safety SRP, Inc. alertness tool. Employees and managers were given the option to complete a survey, and managers and Predictive Safety SRP, Inc. personnel made employees aware of the study. Employees and managers each completed one 10-minute survey on their perceptions of alertness testing after learning about AlertMeter®, but prior to the implementation of the alertness testing tool. Work sites were also given the option of receiving training on how to use the alertness test prior to beginning the study, although this was not required and up to the worksite leadership's discretion because a manual was also distributed.

Although outside the scope of this study (as we captured only participant feedback on the tool prior to full implementation), we include a description here of how the app was used. Once the AlertMeter® was adopted and after survey data

were collected, employees were encouraged to take the alertness test prior to starting each work shift. Managers received notifications immediately when their employees scored outside their normal range, which could indicate diminished alertness. Dashboards presenting employee alertness scores included color-coded notations to reflect scores outside normal range for individual employees. Discussions with employees to identify appropriate countermeasures were encouraged through the elective training and provided manual, but more emphasis was placed on prompting a discussion with the employee to better understand contributing factors to their diminished alertness.

This study received Institutional Review Board approval. Informed consent was obtained from all participants included in the study, in which they were informed that they could withdraw from the study at any time without penalty, with a highlighted section of the consent form that indicated: "Whether you decide to participate in this survey research or not will have no impact on your employment." No names or personal identifiers were collected. Survey data were obtained by the research team, rather than the work sites, and responses were combined such that findings were only shared in aggregate form to protect the anonymity of participants.

Work Sites & Participants

Employees and managers from four work sites participated in the study ($N = 38$ employees, $N = 17$ managers). The work sites included a fire department, a construction engineering firm, a commercial and industrial construction contracting company, and a precious metals mining company, across two states in the Mountain West region of the U.S. Sample characteristics are provided in Table 1. As a result of the small sample size captured in this study and the few work sites involved, we report on all data in aggregate across worksites. Participating work sites were recruited to participate in conjunction with their trial period of the alertness tool. The total sample size was limited due to the participating work sites choosing to first pilot the alertness app with a small group of employees.

Measures

In the employee survey, we assessed openness to alertness testing, perceptions of employees' alertness at work, workplace safety incidents, near misses, safety climate (i.e., perceptions of one's direct supervisor's support for workplace safety; Zohar & Luria, 2005), and safety compliance (i.e., adherence to workplace safety protocols and procedures; Neal & Griffin, 2006). In the manager survey, we assessed perceptions of the anticipated effect of alertness testing, perceptions of employees' alertness at work, and safety climate (i.e., their self-reported support for workplace safety). See Table 2. Participants were prompted to provide open response data to elaborate on their responses, as well. For all measures with more than one item (i.e., safety climate and safety compliance), mean scale scores were

Table 1 Sample characteristics

	N	Gender	Race	Age	Work Schedule	Tenure
Employees	38	74% Men, 26% Women	79% White, 13% Hispanic, 5% American Indian or Alaska Native, 3% Asian Indian, 3% Pacific Islander	$M = 38$ years, $SD = 12$ years	51% Daytime, 32% Variable, 14% 48-96, 3% Rotating	$M = 6$ years, $SD = 5$ years
Managers	17	77% Men, 23% Women	100% White	$M = 43$ years, $SD = 13$ years	65% Regular, 23% Variable, 12% 48-96	$M = 7$ years, $SD = 6$ years

Note. All sample characteristics are based on available data (i.e., divided by the number of responses, rather than the total sample size). For example, managers' race is reported as 100% white because 13 of the 17 responders were white, but 4 managers did not respond to the question. Values are rounded to the nearest whole number (and may sum to a value greater than 100%).

Table 2 Survey measures

Employee Survey				
Measure	**Items**	**Example Question**	**Response Options**	**Participant Responses**
Openness to Alertness Testing	1	*To ensure that workers are alert and fit-for-work for every shift, how open are you to using alertness tests at the start of your shifts, i.e., short computer "brain games"?*	0 = Opposed, 1 = Not Very Open, 2 = Not Sure, 3 = Open, 4 = Very Open	*M* = 2.89 *SD* = 0.83 Range: 1–4
Alertness Perceptions	1	*How often do you think employees work here while they are not fully alert?*	1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often	*M* = 2.70 *SD* = 0.70 Range: 1–4
Workplace Safety Incidents	1	*In the past six months, how many incidents at work have you been involved in that resulted in injury to yourself or others, or damage to property/equipment?*	Numeric Entry	Range: 0–2
Near Misses	1	*In the past six months, approximately how many near misses have you been involved in or observed?*	Numeric Entry	Range: 0–6
Safety Climate (Zohar & Luria, 2005)	3	*My direct supervisor discusses how to improve safety with us.*	1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	*M* = 3.94 *SD* = 0.72 Range: 2–5
Safety Compliance (Neal & Griffin, 2006)	3	*I carry out my work in a safe manner.*	1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	*M* = 4.42 *SD* = 0.43 Range: 3.67–5
Manager Survey				
Measure	**Items**	**Example Question**	**Response Options**	
Anticipated Effect of AlertMeter®	1	*Rate the effect that you think the AlertMeter® will have on improving safety at your company.*	0 = A Negative Effect, 1 = No Effect at All, 2 = A Slight Effect, 3 = A Moderate Effect, 4 = A Significant Effect	*M* = 2.29 *SD* = 0.99 Range: 1–4

Table 2 (continued)

Alertness Perceptions	1	*How often do you think employees work here while they are not fully alert?*	1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often	*SD* = 0.49 Range: 3–4	*M* = 3.35
Safety Climate (Zohar & Luria, 2005)	3	*I am strict about working safely when my employees are tired or stressed.*	1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	*SD* = 0.43 Range: 3.67–4	*M* = 4.35

computed and used in all analyses. Given that safety climate and safety compliance response options are on one-to-five Likert-type agreement scales, percentages reported for these multi-item measures reflect "agreement" if mean scores are four or greater.

Results

Employee Results

Results indicate that 71% of employees who completed the survey were open or very open to using an alertness test at the start of their shift, none were opposed, and the remaining 29% were either not sure or not very open.

Responses to an open-ended question about openness to alertness testing illustrate the reasons for the employee ratings. For example, employees who were open to the idea explained:

"I think it's a great gauge to determine risk levels on a day to day basis, and to alert a manager to an employee who may not be at full potential on any given day. This would allow the manager to then provide assistance to that employee."
"Have been in construction trade a long time, and interested in the science of the AlertMeter in being a viable predictive manner to prevent mishaps and or accidents on the job site"
"It takes less than a minute, and I feel like it gives a better insight into a person's state of mind on a given day."

Alternatively, employees who were not open or unsure about using an alertness test at work described:

"I don't know what it is measuring and why."
"I am not sure of the effectiveness of the games"
"I've never done anything like this"
"Seems like a waste of time."
"I do not have time for brain games."

One participant shared concerns about potential age-related bias in the test:

"…it just seems like a not alert older generation employee is at a disadvantage."

Interestingly, most employees reported being relatively safe at work, particularly for the hazardous nature of the industries sampled (i.e., construction, mining, firefighting). Regarding objective safety indicators, most employees (89%) reported experiencing no incidents in the previous six months that resulted in injuries or damage to property/equipment. The four participants who reported having safety incidents described a back sprain, pulled muscle, minor hand injury, and damaging a fire truck on the firehouse garage door. Witnessing or experiencing near miss

Table 3 Correlations among variables from the employee data collection

	1	2	3	4	5	6
1. Openness to Alertness Testing	-					
2. Alertness Perceptions	-.06	-				
3. Workplace Safety Incidents	.37*	.33	-			
4. Near Misses	-.07	.05	-.12	-		
5. Safety Climate	.37*	-.02	.02	-.11	.82	
6. Safety Compliance	.20	-.03	-.07	-.14	.45**	.73

Note. We urge readers to interpret these correlations provisionally, given the small sample size ($N = 38$). Relatedly, we did not explore correlations among the variables for the manager data set due to the especially small sample size ($N = 17$). Alpha reliability coefficients for multi-item measures are provided on the diagonal.

* $p < .05$, ** $p < .01$

incidents was notably more frequent, though still not experienced by most (76%) employees in the last six months. Moreover, nearly all (97%) employees reported that they use the correct safety procedures in their job and complete their work with the highest level of safety (i.e., high safety compliance). Despite reports of strong safety behaviors, 73% also indicated that they think employees either sometimes or often work while they are not fully alert. Furthermore, about half (54%) of employees reported that their direct supervisor demonstrates concerns for and proactively addresses safety-related issues, which was positively correlated with ratings of openness to the alertness test (See Table 3). This suggests that employees who work for supervisors that support the safety climate of their workplace were also more open to using alertness testing tools.

Manager Results

Most managers (76%) who completed the survey anticipated the alertness test to have at least some effect on improving safety in their workplace. Specifically, 12% of managers expected the alertness test to have a significant effect, 29% expected a moderate effect, 35% expected a slight effect, and 24% thought it would not impact workplace safety. No managers expected alertness testing to have a negative effect.

Managers were also invited to explain their ratings. Those who believed in the effectiveness of the new alertness testing tool described:

> *"We already are a safe company, but I chose to rate this as significant because even a single safety issue or incident can be significant on its own. Therefore, I'm always glad to implement a new safety measure."*
> *"I think it will make employees and managers more aware of their mental alertness."*
> *"I strongly believe people will alter their evening or early morning rituals knowing that they are being monitored."*

"I believe that for the most part we do well in identifying fatigue in the workplace, but this will help identify those that fall through the cracks."

One manager who believed in the potential effectiveness of alertness testing also shared concerns:

"I like the idea of the test, but the practicality and management of the program is a bit up in the air for me as to how implementation will be achieved."

On the other hand, some managers were not convinced about the effectiveness of the newly implemented alertness testing tool:

"I don't know enough about it yet."
"Not being sure of what we will do as a company when someone gets a low score."
"Not sure of the benefits at this point."

Like employees, managers also rated themselves as supporting their employees' safety at work; nearly all managers (94%) reported that they discuss and enforce safety-related practices with their employees. However, all managers (100%) reported a belief that employees work while they are not fully alert.

Summary of Alertness Testing Perceptions

Our results shed light on the perceptions employees and managers in safety-sensitive industries have towards a new tool to assess employees' pre-shift alertness. Both employees and managers in this study saw the value in using alertness testing as a means of reducing fatigue and improving workplace safety, as they were largely open to and optimistic about the implementation of a new safety tool. Reluctance and apprehension to using a new alertness testing tool was due to uncertainty about how it works and whether it is effective, ambiguity surrounding the implementation of the tool, perceived lack of time, and concerns about the fairness of the tool. Notably, employees who work for managers who support the safety climate of their workplace were more open-minded to the new safety tool. Despite a staggering proportion of employees who enact safety behaviors and managers who support workplace safety, employees still experienced some safety incidents and near misses at work, and most believed that employees work while fatigued, highlighting the potential utility of alertness testing.

Although all employees and managers at the participating work sites were asked to complete the surveys, the primary limitation of this study was the small sample sizes ($N = 38$ employees, $N = 17$ managers), preventing the use of advanced inferential statistics. It is important to note that participation was voluntary, and the work sites were piloting the alertness tool first with a small group of employees to inform their decision about broader implementation. Further, both managers and employees shared that a lack of buy-in from managers may have negatively affected the regular use of the alertness tool among employees. While our results captured perceptions of the specific alertness tool that was implemented across worksites (i.e., AlertMeter®), it is possible that these beliefs would generalize to different platforms, as well. Despite these

limitations, there is a need for research, development, and implementation of preventative measures that improve workplace safety, and our results provide valuable insight on employee and manager impressions of a new alertness testing tool, which will help practitioners anticipate how their workforces might respond to alertness testing.

Alertness Testing Recommendations for Practitioners

Drawing from information gleaned from employee and manager reports across four worksites implementing a new alertness testing tool, in combination with existing best practices, we provide the following recommendations for practitioners interested in implementing workplace alertness testing.

How do I Choose an Alertness Test?

Validity Evidence

When selecting a commercially available alertness testing platform, practitioners should ensure that the platform has been well-validated scientifically, meaning that the platform has undergone rigorous evaluation in laboratory and/or field settings before it was released commercially. Validity indicates that the test a) measures what it is intended to measure (e.g., has been shown to be sensitive to sleep loss or time spent working), and b) has been shown to predict important safety-related outcomes (e.g., injuries, near misses). Validity evidence is provided in grant-funded project reports, published white papers, and, most rigorously, in published peer-reviewed journal articles. Given that workplace alertness testing is a relatively new concept, efforts to validate related technologies are ongoing, and practitioners should consider evidence-based criteria when evaluating alertness testing products. Stakeholders (e.g., employees, managers, organizational leaders) may be less familiar with the concept of validity, providing an opportunity for practitioners to convey the importance of evaluating validity evidence when selecting an alertness testing tool.

Feasibility

Once validity evidence has accumulated, practitioners should also consider feasibility factors to assess whether a given alertness test is right for their workforce. For example, is the test brief and easy for workers to access given the limitations of the work site (e.g., does it rely on internet access, can it be taken on a smartphone rather than a computer)? Additionally, does the platform allow for multiple testing periods during the shift, if desired, and can notifications be enabled to encourage workers to complete the test at a given time? Feasibility should also be determined by whether the platform allows for the practitioner and/or managers to access alertness

data quickly and easily. A testing platform may also prove ideal to a practitioner if the developer agrees to provide initial and ongoing support (e.g., proper training for users, customization of the platform).

How do I Implement Alertness Testing?

Focus First on Safety Climate and User Buy-In

Safety climate reflects shared perceptions of the value of safety in one's workplace and depends on leadership and managerial support for safety (Zohar & Luria, 2005). Results from our study indicate that employees were more open to alertness testing when a strong and positive safety climate was already in place. This suggests that care should be taken to ensure safety-related procedures are established more generally before alertness testing is implemented, that leaders are advocates of safety, and that employees trust their organization with safety-related issues.

Participation in the survey data collection and use of the alertness testing tool were low, and partially attributed to a lack of manager buy-in. Our results indicated that although employees and managers were open to alertness testing, they also wanted and needed substantial background information on the test to be convinced of its utility. It is necessary to communicate clearly, honestly, and sensitively with managers and employees about an alertness test's purpose and potential benefits, how the data will be used, and how employees will be protected in the process. This information can be communicated in pre-implementation trainings with employees and managers. To further ensure high participation in future implementation efforts, strong and consistent messages should be conveyed from multiple sources; researchers can send reminder emails, signage can be posted at worksites, employees can create reminder alerts on their phones, and managers and employees can be asked to remind each other to take alertness tests and related surveys.

Integrate Testing with Existing Workplace Procedures

When implementing alertness testing, it is useful for practitioners to anticipate how the alertness testing can be integrated seamlessly into existing workplace procedures. For example, managers should ensure ample time at the start of shifts to allow employees to complete tests. It is also important to consider and address all obstacles to consistent, daily testing prior to testing roll-out. Practitioners should collaborate with human resource departments to develop policies and procedures that are legally defensible regarding how employees will be informed about the implementation of testing, in addition to how data will be used and stored (e.g., the Society for Human Resource Management, 2019, provides recommendations for managing potential legal issues related to employee monitoring and surveillance).

Ethical Considerations Related to Alertness Testing

It is critical that organizations, practitioners, and management alike are cognizant of ethical considerations when implementing alertness testing.

The Need for Alertness Testing

Workplace alertness testing should only be implemented when it is necessary and appropriate, such as in safety-sensitive industries that pose risks to employees and the public. All occupations benefit from alert employees, yet it may not be ethical to require all employees to take pre-shift alertness tests. Illustratively, although web developers, writers, or event planners may produce lower-quality work on days they have diminished alertness, they are likely not jeopardizing the health and safety of themselves or others. On the other hand, there are grave potential consequences for power plant operators, pilots, or commercial truck drivers who work while fatigued. It is possible that the habit of taking pre-shift alertness tests could empower employees to use alertness testing as a safety measure outside of work as well (e.g., prior to commuting), which could be explored in future studies. Ultimately, the need for alertness testing should be tied to protecting individuals' safety and well-being, and we recommend only implementing alertness testing when it will serve to better protect workers and/or the public.

Additionally, when alertness testing is needed, the test chosen, as mentioned earlier, should have strong validity evidence supporting its use. If a test does not accurately measure alertness or does not predict important and relevant outcomes, employees would be subjected to an undue burden of taking alertness tests. Consequently, employees would likely experience unnecessary changes to their working situation due to inaccurate testing results, and feedback about their alertness levels could be deceptively alarming to the employee.

Protecting Employees

Fatigue is associated with poor physical and psychological health, and fatigue can be due to caregiving responsibilities (e.g., parenting an infant) or individual differences in life stage (e.g., age, menopause). Indeed, concerns about potential bias were mentioned by participants in our study. For these reasons, beyond using alertness testing for same-day non-punitive reassignments to reduce safety risks (e.g., completing clerical tasks rather than operating machinery), we urge against using alertness tests for administrative decisions (e.g., promotion, termination, permanent reassignment). When diminished employee alertness necessitates a temporary reassignment, managers should act with compassion and frame the decision around concern for safety, rather than as a punitive measure. There are both ethical reasons (e.g., equitable treatment of workers) and legal reasons (potentially falling under the Americans with Disabilities Act, Title VII of the Civil Rights Act, or The Age Discrimination in Employment Act) to avoid using alertness tests for administrative decisions.

To achieve this, managers should receive pre-implementation training that explicitly identifies options for addressing diminished employee alertness. Trainings can identify when reassignment is warranted and the types of reassignments that can be used. Training content can also focus on teaching managers specific behaviors for having productive and supportive conversations with their employees about their alertness. Moreover, it would be worthwhile for upper-management and leaders to intervene and correct managers who use employee alertness information inappropriately (e.g., in controlling or manipulative ways, for administrative decisions), or who use a reprimanding approach. Organizations can also create a reporting system for employees to express concerns they may have about decisions that are made based on their alertness data. Furthermore, managers should be aware of and provide resources to employees who are habitually fatigued. These resources may include healthcare, employee assistance programs, childcare, drug and alcohol rehabilitation resources, reduced workload, on-site nap spaces, and flexible schedule options.

It is also critical for organizations and managers to understand that without extensive validity studies, in addition to validity studies taking place in the specific industry and job in question, there is little ability to determine the exact threshold at which a given level of diminished alertness can be classified as "unsafe". Users of an alertness test should be wary of any company that claims to have identified such a threshold. Moreover, acknowledging that every individual will have a different baseline level of alertness, a simple practical recommendation would be to focus more on how an individual scores on a given day relative to how they typically score, with the most attention paid to extreme scores, when considering task reassignment. Managers should also work in collaboration with employees to make these decisions and not rely solely on the tests, given the limitations of most existing alertness tests.

Additionally, even when used in the interest of workplace safety, there may be unintended psychological and interpersonal implications of alertness testing. Being monitored by one's workplace may feel like an invasion of privacy. For instance, job reassignments will be apparent to an employee's coworkers, who may inquire about why they were reassigned. Further, alertness testing may make employees feel like their managers or workplace does not trust them to come to work alert. These experiences could lead to negative emotions (e.g., anxiety, embarrassment), as well as defensiveness or resentment towards coworkers, managers, and the organization. It would be worthwhile to build on research related to electronic surveillance at work to explore the potential psychological impacts of workplace alertness testing, as well (e.g., Jeske & Santuzzi, 2015; West & Bowman, 2016).

Protecting Employee Data

Care should be taken to protect employees' alertness data, given that fatigue levels can be related to health, such as chronic or acute illness, psychological disorders, sleep disorders, substance abuse, and medications. If this information is shared with others, it could potentially damage an employee's reputation, how they are treated at work, and/or may foster feelings of distrust towards managers and the organization. Thus, it is imperative that employee data, such as alertness test results, be kept private (e.g., between

a safety manager and employee) and not shared with others in the workplace. When selecting an alertness test, organizations should thoughtfully consider what devices the testing will take place on, as cloud-based data may not necessarily be secure. Given that employees may not all have access to their own smartphones, organizations could provide technological resources like secure tablets for testing to be completed on.

Lastly, careful thought should be put not only into data security, but also who employees feel comfortable having their data shared with during the testing process and after. For example, researchers at universities are excellent research partners because they have training and certifications in conducting ethical human subjects research and whose studies must undergo rigorous ethical checks by their IRB. Union officials who represent the best interests of the employee may also be involved and have interest in understanding alertness data. However, employees should always consent to having their data shared with an external party and should be assured that their data will be anonymous and aggregated with all employee data so that individuals cannot be identified. We also recommend that practitioners and managers learn about research-related ethics, as well, such as through independent learner courses offered by the Collaborative Institutional Training Initiative.

Conclusion

Workplace alertness testing holds promise for protecting workers and the public, though little is known about employee and manager perceptions of alertness testing. Quantitative and qualitative data from employees and managers in four safety-sensitive industries suggests that employees, especially those with direct supervisors who support safety at work, are open to alertness testing. Similarly, managers reported believing in the potential effectiveness of workplace alertness testing. However, there are challenges associated with widespread adoption of alertness testing at work. Therefore, although alertness testing can meaningfully benefit workplace safety, we urge practitioners to carefully consider how to implement alertness testing effectively and ethically.

Author Contribution All authors contributed to the study conception, research design, survey preparation, and data collection. The first draft was written primarily by Rebecca M. Brossoit and Tori L. Crain and all authors provided feedback and revisions on versions of the paper. Grant funding for this project was obtained by Tori L. Crain (PI) and Lori Guasta (Co-PI). Analyses were performed by Rebecca M. Brossoit, Shalyn C. Stevens, and Jacqueline R. Wong. All authors read and approved the final manuscript and contributed to the revision process.

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Data Availability Data, material, and code will be made available upon request.

Declarations

Ethics Approval and Informed Consent This study received IRB approval from Colorado State University. Informed consent was obtained from all participants included in the study.

Competing Interests A contributing author (Lori Guasta) was formerly employed by the developer (Predictive Safety SRP, Inc.) of the alertness test referred to in this report (AlertMeter®) and currently holds stock in the company. The other authors have no relevant financial or non-financial interests to disclose.

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CORRECTION

Correction to: Alert at Work? Perceptions of Alertness Testing and Recommendations for Practitioners

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In this online published article, the abstract was inadvertently omitted.

Please find the abstract below.

Springer wishes to apologize for any inconvenience caused.

Abstract
Around-the-clock, 24/7 operations are common in many industries, yet contribute to employee fatigue, which can have grave consequences for worker safety, public health, and the environment. Alertness testing is one option for identifying and mitigating issues related to fatigue at work. We review alertness testing options, including fatigue risk management systems and app-based tools, and share results from a study evaluating employee and manager perceptions of alertness testing. Despite a growing body of research on the validity of app-based alertness tests, it is also critical to understand how these tools are perceived by workers and management. To investigate perceptions of alertness testing, mixed-method data were collected from organizations across four safety-sensitive industries (i.e., a mining

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company, fire department, and two construction companies) that were in the process of implementing an alertness testing platform. Results suggest that employees and managers are open to and optimistic about implementing new alertness testing safety tools. Employees in work environments with strong managerial support for safety were particularly open-minded to alertness testing at work. However, some employees and managers expressed reluctance towards alertness tests. We provide recommendations for how occupational health and safety professionals can effectively select alertness tests and implement alertness testing. Ethical considerations related to identifying whether workplace alertness testing is needed, and how to protect employees and their data, are discussed.