SAFETY MANAGEMENT

Peer-Reviewed

SERIOUS INJURI

Why Are They Constant W

By Carsten Busch, Cary Usrey, James Loud, Nick Goodell and Rosa Antonia Carrillo

CSB HAS COMMENTED that the oil drilling industry focuses excessively on personal workplace injuries and not enough on higher consequence activities to help identify danger signs before catastrophic events occur. After the *Deepwater Horizon* investigation, CSB concluded that too much industry attention was paid to controlling relatively minor personal injuries at the expense of looking more deeply at process safety and other high consequence activity that could lead to more serious incidents (Associated Press, 2012). Konrad and Shroder (2011) also note:

> The intense concentration of Transocean and BP on relatively minor slips trips and falls had struck some as odd. They were, after all, sitting directly on a cavern of highly pressurized, highly flammable material that could erupt with horrifying consequences.

The U.S. total recordable incident rate has declined sharply in recent years and reached an all-time low in 2017 (BLS, 2018). This would be cause for celebration if not for the news that total worker fatalities increased in both 2014 and 2016, and rose to levels not seen since 2008 (BLS, 2018). In addition, the U.S. fatality rate has remained essentially flat for more than a decade while the average cost of workers' compensation claims has increased significantly (Manuele, 2008). Other developed countries are doing a better job in controlling fatalities, most notably the U.K., with considerably lower (> 50%) fatality rates. As many have noted, an obvious and growing gap exists between the rate of incidents (as reported and often manipulated) and the frequency of serious injuries and fatalities (SIFs; Ivensky, 2017; Loud, 2016; Martin & Black, 2015).

Not surprisingly, concern that we are not doing enough to control SIFs is also growing. In 2011, Terrie Norris, then-president of ASSP, pointedly stated, "A statistical plateau of worker fatalities is not an achievement, but evidence that this nation's effort to protect workers is stalled. These statistics call for nothing less than a new paradigm in the way this nation protects workers." Is enough being done? Is just doing more of what we have always done the answer? Does society accept worker fatalities as part of doing business? Fortunately, the answer to all these questions appears to be leaning toward "no." Clearly there is room for improvement.

There is no doubt that Herbert Heinrich made important contributions to the safety practice (Heinrich et al., 1980; Manuele, 2002). His works have been much repeated and studied over the years. However, his ratio of 1:29:300, also known as Heinrich's triangle or pyramid (Figure 1), has been misinterpreted and misused to the point of abuse, and companies and workers are ultimately paying the price due to misdirected preventive efforts.

Heinrich's triangle suggests that, on average, for every major incident, 29 minor incidents and 300 incidents with no injuries occur. Heinrich believed that the predominant causes of no-injury incidents are identical to the predominant causes of incidents resulting in major injuries. From there, safety practitioners posited that if they concentrate efforts on the types of incidents that occur frequently (at the bottom of the triangle), the potential for severe injury (the top of the triangle) would be addressed as well. Unfortunately, a review of available data indicates that this is a patently false premise (Busch, 2016; Manuele, 2008; Rebbitt, 2014).

Recent investigations of incidents resulting in fatality or serious injury reveal that the causal factors generally associated with SIFs are not closely linked to causal factors of incidents that occur frequently and result in minor injury (Krause & Murray, 2012; Manuele, 2014; Mattis & Nogan, 2012). Bureau of Labor Statistics data support this conclusion, as detailed in the comparison of fatal and nonfatal injury data (Figure 2).

Why Are We Focused on Collecting the Wrong Data?

So, how did we end up with significantly lower injury rates while still experiencing high rates of SIFs? One consideration, of course, is the tendency to underreport nonfatal injuries to improve lagging indicator optics. OSHA estimates that more than half of serious nonfatal injuries likely go unreported (Michaels, 2016). It is considerably more difficult to pencil whip fatalities. But this is only part of the safety data issue. Gantt (2014) offers this explanation:

> When it comes to identifying "safe" and "unsafe" behaviors, your employees are far more likely to identify obvious "unsafe" behaviors that lead to smaller accidents than they are to identify less obvious behaviors that are in more of a grey area. Coincidentally, these

KEY TAKEAWAYS

- **OSH professionals are not taking full advantage of safety data to help prevent serious injuries and fatalities (SIFs). We have over-focused on accumulating common behavior and incident data that are rarely relevant to SIF prevention.**
- **Grouping data according to control(s) and risk potential is more useful in identifying SIF precursors than the common practice of grouping by chance consequence.**
- **Looking deeper at available data for both social and technical systems within a comprehensive safety management system can significantly improve the identification of factors that lead to catastrophic incidents.**

ES & FATALITIES
hile Injury Rates Decrease?

less obvious "unsafe" behaviors are more associated with serious injuries and disasters.

One safety provider that aggregates safety data from inspections, assessments and observations has accumulated more than 450 million discrete bits of work site data from various sources to help companies measure and identify leading indicators of risk (Bernini & Usrey, 2018). Their extensive data support the conclusion that typical safety findings are heavily focused on easily observable behaviors and conditions, such as general PPE use, with relatively little attention paid to tasks and hazards that are more likely to involve SIFs, such as work at height, confined spaces and electrical exposures (Figure 3, p. 28).

Further to this point, the classification of unsafe findings data show that low consequence findings are reported much more frequently than high consequence findings (Figure 4, p. 28). Low and medium severity findings are linked to low consequence potential. In the example shown in Figure 3 (p. 28), roughly half of the findings involve PPE such as safety glasses and hearing protection. Housekeeping items and minor administrative items such as conducting a toolbox talks comprise another 12%. High and life-threatening severity findings are linked to high consequence potential. Examples include work at height, electrical exposures, confined spaces, struck-by and caught in/between hazards, and work with hazardous materials. As shown in Figure 5 (p. 28), on average, there are about five times as many low and moderate severity unsafe observation findings as high or life-threatening findings. This is not surprising given that many serious injury incidents occur during nonroutine, infrequently performed work with high energy sources (Manuele, 2008).

The triangle in Figure 5 (p. 28) is not meant to replace Heinrich's. It simply demonstrates the proclivity to focus on routine, low consequence conditions and behaviors, not a guaranteed ratio of future outcomes, especially those that have the potential to be serious in nature.

No Predictive Ratio Applies to All Injuries

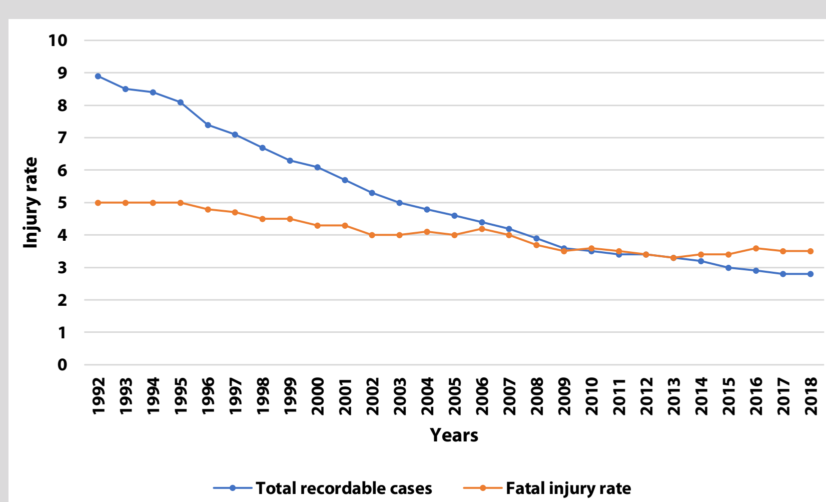
To be clear, there is no predictive ratio that applies to all injuries. Several recent studies have actually shown little correlation, and negative correlations in some cases, between improving rates of minor injury and SIFs (Loud, 2016). Busch (2016) states that such ratios are:

> . . . useless because Heinrich himself already said these ratios would vary from case to case. Discussions like these take away the attention from the essence of the

FIGURE 1
THE HEINRICH LEGACY

Heinrich's triangle or pyramid suggests that, on average, for every major incident, 29 minor incidents and 300 incidents with no injuries occur. This ratio has been misinterpreted and misused to the point of abuse.

FIGURE 2
COMPARISON OF FATAL & NONFATAL INJURY DATA, 1992-2018



Note. Data from "Injuries, Illnesses and Fatalities," by BLS, 2020.

FIGURE 3
PERCENTAGE OF OBSERVATIONS BY HAZARD CATEGORY, EXAMPLE

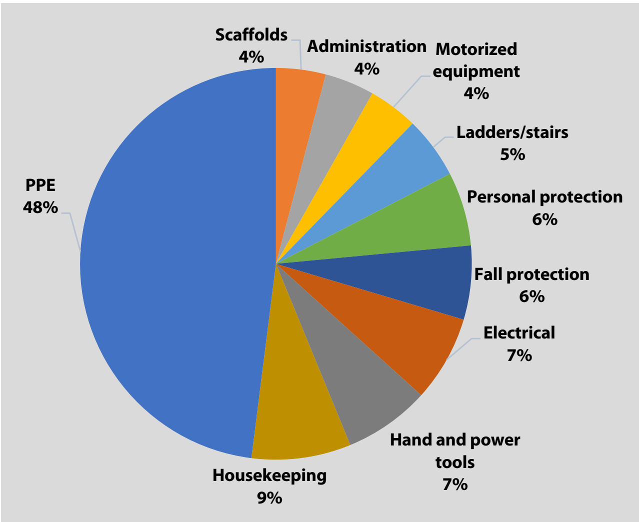


FIGURE 4
SEVERITY DETERMINATION MATRIX

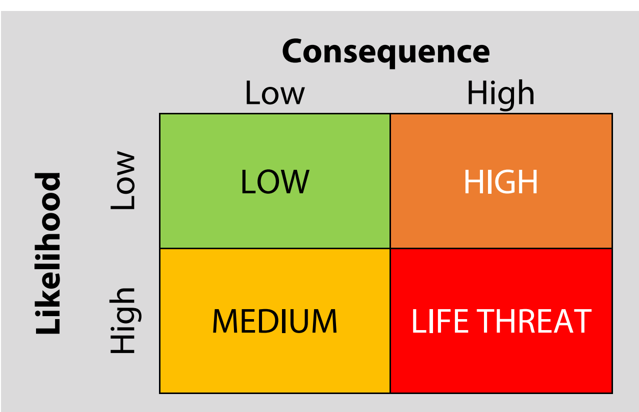
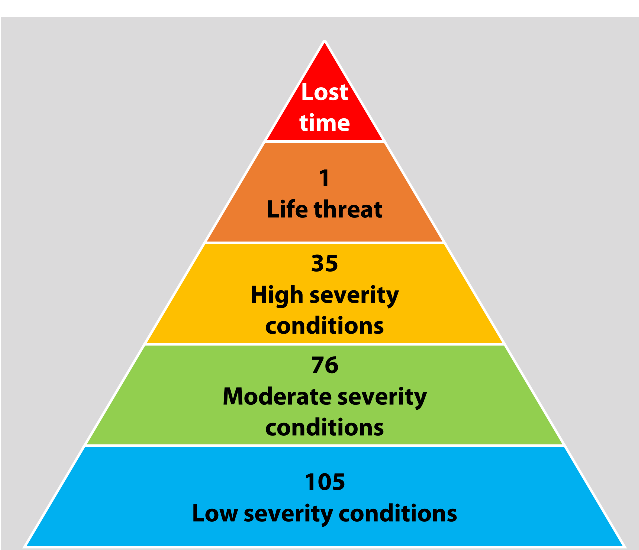


FIGURE 5
COUNT OF AT-RISK FINDINGS, BY SEVERITY, PER LOST TIME INJURY



> triangle, which is all about learning from weak signals. Further, it is wrong to talk about major and minor accidents since there is no such thing. It's the consequences that are major or minor. So, why wait for an accident with major consequences? Reacting to a similar incident with minor consequences (preferably even a near miss) can remove the causes and prevent an accident with major consequences from happening. (p. 104)

Even Heinrich (1941) himself said, "Prevent the accidents and the injuries will take care of themselves" (p. 27).

A central element in the triangle metaphor is the so-called common cause hypothesis (CCH), a term that Heinrich himself never used and probably did not fully understand because he changed and omitted some elements generally associated with CCH between the various editions of his seminal book, *Industrial Accident Prevention*. The CCH asserts that certain incidents, regardless of the severity of their outcome, share causal paths (Busch, 2012). Therefore, removing or mitigating the causes of incidents with little or no consequence can help to prevent more severe incidents. The benefit of applying the CCH is that one does not have to wait to take safety measures until after an incident with a major consequence, but instead can focus on incidents with similar causes, both direct and contributing, without the harmful consequence. Since these "minor" incidents or precursors occur more frequently than the major ones, there are many chances for improvement at a rather low "price" (loss). Looking at "minor" incidents more carefully allows organizations to identify larger system weaknesses that can serve as pointers to more serious issues and potential failures (Conklin, 2012).

One can even go one step further than just looking at "minor" incidents, but also at precursor incidents or even at proactive/positive precursors that are found in observations of work performed safely. After all, a neglected or latent precursor (e.g., training deficiencies, production pressure, deferred maintenance) may become a significant factor leading to future, more serious incidents. In the second edition of his book, Heinrich (1941) presents the pyramid and states that "for every mishap resulting in an injury there are many other similar accidents that cause no injuries whatever" (p. 26). A keyword that is essential to understanding the CCH and applying the pyramid correctly is "similar."

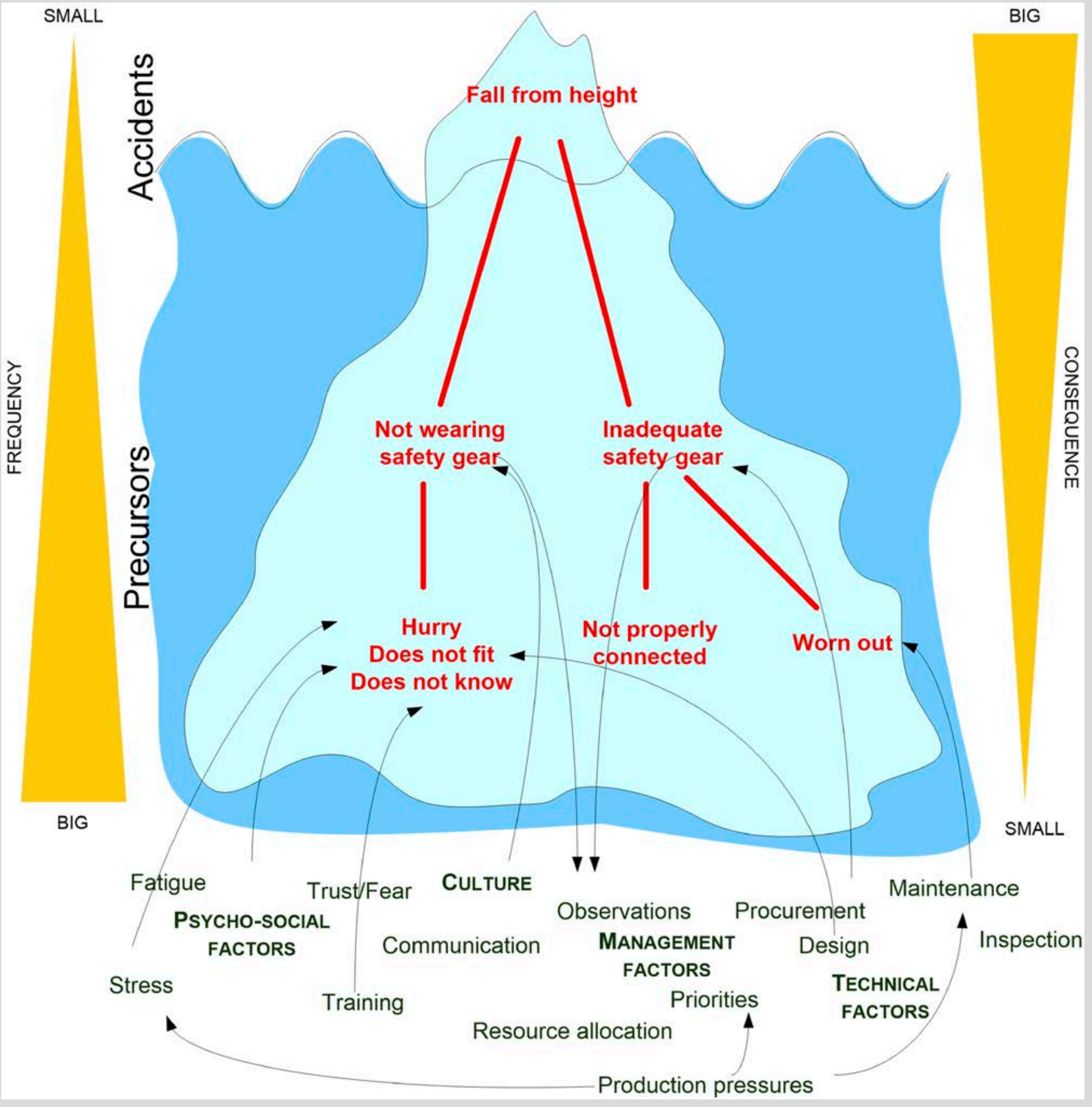
Consequence & Cause Are Not Related

When considering Heinrich's pyramid concept, it is crucial to make sure that one does not blend unrelated types of incidents. All too often, this is exactly what happens; incidents are lumped together to get a calculated injury rate. This creates the illusion that reducing incidents with minor consequences will automatically reduce the number of major incidents—a seriously flawed concept except in cases of common cause. To illustrate this point, reacting to routine occupational trip, slip and fall hazards will usually not contribute to preventing more serious incidents such as explosions, simply because the causal factors are entirely different. The lack of similarity of the incidents (fall vs. explosion) should already be a major clue.

Another problem with the traditional sorting on consequence is that consequences occur rather randomly and do not, in general, reflect a strong correlation to causation of the incident. So, instead of picturing one triangle (like Figure 5), it would be better to break it up in several smaller triangles with similar causal pathways or scenarios. Of course, one must remain practical, but any company will be able to, without much problem, define a limited number of relevant hazards, risks or types of incidents that can be grouped

FIGURE 6

ICEBERG DIAGRAM REPRESENTING DIRECT, CONTRIBUTING & LATENT FACTORS



due to similarity and causal connection. Examples include handling chemicals, working at height or vehicle operations. Figure 6 illustrates an example of a fall-from-height event, pictured as an iceberg, with a simplified causal tree and contributing factors. The iceberg is represented to show that the readily visible features of an incident are only a small fraction of the system deficiencies that led to the incident where there is a dynamic system that has a host of latent error traps that can exist even in successful work.

The tip of the iceberg consists of the actual falls, which may have varying consequences. The proximate causes for the fall illustrated in Figure 6 are failure to wear safety gear and inadequate controls. The farther down the iceberg we go, we find the contributing factors less and less tangible. We can identify inadequate procedures that act, and interact, to set us up for an incident. But the most intangible and perhaps more powerful factors are at the bottom of the iceberg. Trust, fear, culture, psychological safety, production and economic pressures influence the decisions that lead to success or failure.

It is also possible to find positive or leading precursors, including a workplace culture in which using safety gear is "the way we do things around here," effective training of personnel, procurement of adequate, comfortable and well-fitted gear and the existence of multiple feedback loops (e.g., observations, inspections, audits, coaching). It is good practice to use these positive precursors as leading indicators for safety and is a far more effective method than merely counting the number of significant injuries due to falls. It is important to keep a clear eye on the causal connections and interconnections. The best forms of maintenance (the far-right branch of the causal tree) will not help if one does not use the safety gear (the left branch). Application of simple logic and regular critical checks of work done rather than imagined should keep you on the right path as well as provide proactive heuristics to assess the efficacy of the safety controls.

Areas for Further Investigation: Weak Signals & Drift

It has become increasingly clear that safety cannot be effectively managed by traditional approaches that focus primarily on specific and independent controls. Safety must be integrated along with other aspects such as design, construction, training, worker engagement, operation and maintenance. Additionally, looking deeper at both social and technical systems within a comprehensive safety management system can significantly improve the identification of factors that lead to catastrophic incidents.

Collecting data is one thing; interpreting it correctly and taking appropriate preventive action is more difficult. Perception studies have taught us that we tend to see what we expect and desire, not necessarily reality (Krause, 2008). Nowhere is this more prevalent than at the bottom of the iceberg (Figure 6, p. 29). For this reason, it is critical to continuously seek feedback from all levels of the organization. It is only by collecting multiple perspectives that we can hope to gain access to the intangible information, much of which falls under the heading of "weak signals."

Weick and Sutcliffe (2001) incorporate the concept of weak signals into safety. Their study found that a major difference between high reliability organizations and other organizations was their response to weak signals. The tendency of lower performing organizations is to give a weak response. Highly reliable organizations are more sensitive to weak signals and are thus more likely to detect its significance and respond strongly when needed. Weak signals can be physical, such as a small leak, or emotional, such as signs of stress, indicating that there may be deeper problems. The *Deepwater Horizon*, for example, exhibited numerous unexamined weak signals (e.g., leaking hydraulic fluid, deferred maintenance on the blowout preventer, anomalous pressure readings, production pressure, conflict) that could have served as warnings to avoid or mitigate the explosion that killed 11 and resulted in the largest accidental oil spill in history (Konrad & Shroder, 2011).

Thus, the idea is to catch these weak signals in the form of emotions, mistrust or underlying conflicts before they become physical problems due to lack of awareness or attention. More research is needed to identify better ways to collect and analyze this data. Currently, anonymous survey is the most common process, but it seldom leads to implementing change. Other technologies such as narrative sensemaking show promise for analyzing both positive and negative leading indicators.

The other area the authors recommend for further research is how to manage drift from procedure, another frequently cited precursor to incidents. The safety literature suggests that drift from desired practice is a normal part of operations (Dekker, 2011; Snook, 2000; Vaughan, 1996). Snook identifies practical drift, which is the human propensity to change procedures to make them more efficient. When those changes do not result in negative consequences, they become the new standard (Carrillo, 2013; Snook, 2000). The typical remedy for drift includes more rules and discipline. More rules may make work overly complex and even lead to sensory overload whereby overwhelmed workers tend to tune out the rules to cope and adapt as best they can. In an effort to cut down on this overload, many companies have turned to a few "lifesaving rules," which are usually accompanied by threat of disciplinary action to prevent people from violating procedures. Such efforts often result in ruptured relations between management and workers. Some employees and supervisors have stated that they hide information to avoid getting people fired (Carrillo, 2020).

Open communication about drift and weak signals requires a high level of trust. When people can admit mistakes, ask questions without fear of being ridiculed or speak truth to power about potential problems, we are more likely to surface information that might otherwise be hidden to prevent future tragedies. Creating more rules and procedures increases bureaucracy and does little to manage the unexpected. There are substantial barriers to creating a climate with a high level of trust and open communication. Yet, overcoming these barriers is essential for any organization desiring to minimize its vulnerability to SIFs.

Suggestions for Addressing SIFs With Better Data & Analysis

1. Collect leading indicator data and classify by potential severity (as shown in Figure 4, p. 28).
2. Classify injuries not only by outcome, but also by outcome potential (e.g., SIF potential or not); this will allow even first aid and near hits to be grouped appropriately.
3. Hold critiques of work performed successfully and capture feedback on what went right, as well as problems encountered and opportunities for improvement.
4. Capture data from the performance of high consequence work (SIF potential). Do not just assume this work is performed as imagined, but review it in real time to determine reality. Ask questions and listen to the responses. Do not just assume that work is conducted as directed: look for gaps between work as imagined and work as performed. Focus on SIFs to prevent SIFs.
5. Focus on reducing the seriousness and frequency of human errors and resulting outcomes by improving the interaction between the individuals and the critical systems and recognizing error-likely situations, then applying tools to reduce the likelihood of error. These interactions can be through conversations or by engaging workers in learning teams.
6. Review observation checklists and risk assessments after an incident occurs to ensure that the precursors identified during the incident investigation are listed. Expand observation efforts beyond behaviors to include the environment, systems and interactions between human and machine as well as from system to system. This will ensure that observers can observe them proactively by monitoring the controls in place.
7. Capture data from proactive systems assessments and observations of work as a whole, rather than merely a subset of worker behaviors.
8. Take a deeper look at data from "minor" incidents and findings within common cause classifications (e.g., fall protection, control of hazardous energy). Although minor and more serious incidents generally have different proximate causes, they often share more latent contributing causes. Common factors frequently leading to catastrophic incidents such as inadequate resources, weaknesses in supervision, procedural deficiencies, excessive production pressure and drift may often show themselves in otherwise "minor" incidents and findings. A deeper look at the data from such findings can provide advance notice of significant or growing danger.
9. To achieve the best results from prevention efforts, focus more on the presence and efficacy of controls. Constantly seek out ways in which failure is likely to occur. Respond fervently and proactively to precursor data, also known as weak signals.
10. Stop blaming if you hope to increase worker trust and reporting. Individual behavior is influenced by organizational

processes and values. Shift your questioning from "who failed" to "what failed" and "how can we improve." A positive and constructive response to failure determines the amount and capacity for learning and improving.

Conclusion

Not all activities or environments are created equally. Some things are inherently more dangerous than others. As Hale (2002) says:

> Clearly articulated and understood scenarios must drive prevention activities. We should discriminate between the scenarios that can lead to major disaster and those which can never get further than minor inconvenience. . . . If we tackle minor injury scenarios it should be because minor injuries are painful and costly enough to prevent in their own right, not because we believe the actions might control major hazards. (p. 40)

Additionally, outcomes, which are what injury statistics are based on, do not tell the entire story. A fall from height could result in anything from a fatality to a serious injury to a first-aid incident to no harm at all. The potential consequences were the same, but the outcomes were vastly different. Recognizing the potential outcomes, regardless of the nature of the information received—risk assessment, observation, audit, near hit and especially worker feedback—can help to pinpoint common causal factors and weak signals that can and should be acted upon and improved prior to injury. It is vital to have a learning organization that values such open, nonthreatening communication and promotes trust if we hope to learn from this information sufficiently to take proactive measures to help avoid or mitigate potentially disastrous incidents. **PSJ**

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Carsten Busch, M.Sc., B.Sc., HVK, has more than 25 years of experience in health, safety, environment and quality management. He is senior advisor of occupational safety at the Norwegian Police Directorate and serves as a tutor for the Human Factors and System Safety program of Lund University in Sweden. Carsten is author of several books, and is a member of the Dutch Society for Safety Science (NVVK).

Cary Usrey serves as vice president of operations for SafetyStratus, a software-as-a-service provider for environmental, health and safety. His 30-year career has spanned many roles and industries. He is a frequent speaker at national and international conferences and has authored numerous articles on safety for various publications. Usrey is a member of ASSP's Central Florida Chapter.

James Loud, M.P.H., M.S., is an independent consultant with more than 40 years of experience in various OSH positions and corporate roles. He frequently speaks at conferences, webinars and universities, and has authored many articles on safety management for various publications. Loud is a professional member of ASSP's Four Corners Chapter.

Nick Goodell is director of process improvement with Predictive Solutions/Intelex and has 20 years of experience in software and risk management. He holds an M.B.A. from the University of Pittsburgh Katz Graduate School of Business. Goodell is a member of ASSP's Western Pennsylvania Chapter and a member of the Society's Risk Management Practice Specialty.

Rosa Antonia Carrillo, M.S.O.D., is president of Carrillo and Associates. She is an internationally recognized consultant, speaker and author. Carrillo has 25 years of experience at the operational level with managers, supervisors and employees in North America, Latin America, Central Asia and Bahrain. She is a member of ASSP's Long Beach Chapter, and a member of the Society's Women in Safety Excellence Common Interest Group.