

Saving Lives & Limbs with Big Data

INTELEX
WHITEPAPER

By: R. Gary Edwards, PhD

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R. Gary Edwards, PhD | Advisor, Data Science

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intelex.com

1 877 932 3747
intelex@intelex.com

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Every day of the year, workers lose their lives on the job while many more suffer catastrophic injury. Almost all are preventable. For over a decade, the leading software provider of Environment, Health, Safety, and Quality Management, Intelex Technologies, has been capturing data on the events leading up to workplace incidents, the circumstances surrounding them, and the after-effects. With data from over 1,000 companies worldwide and over 1 million users, Intelex has assembled a Data Science team to help unlock answers on prevention of workplace injury and death. It is early days, but here are key Big Data-driven insights that challenge how companies have been approaching workplace safety up to now.

Challenging the Safety Triangle

Traditional thinking on safety at most companies has entailed an intuitive Safety Triangle. Incidents are organized in a hierarchical pyramid, leading up from least severe to most egregious. The theory is that enterprises should record and remove minor injuries on the bottom, to lower major incidents in the middle and eliminate fatalities on the top. Much of the safety literature reads remarkably like the “broken windows” theory of crime prevention made famous in New York City. Fix the broken windows, remove the graffiti, crack down on minor crimes and the larger crimes will not occur. Similarly, to improve workplace safety, record and eliminate minor safety incidents, which will, in turn, curb the major ones, preventing ultimate tragedies from happening. That is the theory.

While theoretically, this makes sense, the math and the logic does not hold up in every instance. Of course, minor incidents occur more often than major ones, and major ones are far more frequent than fatalities. Favorable to the theory, Intelex’s Data Science team found consistent, moderate correlations among levels of severity in the pyramid. However, just because we observe a pattern, does not mean it is predictive in nature. It is wrong to extrapolate and assume causality, that is, as minor issues are cleared up, major ones will necessarily decrease. We observe instances where these levels move up and down in tandem while in others, they move independently of one another.

The Safety Triangle works in many circumstances when the cause of injury is due to personal failures (humans behaving poorly) versus process failures (machines behaving badly).

Personal failures are avoidable when we consider the “fatal four” injuries in construction: falling, getting electrocuted, getting hit, getting stuck. Easily illustrated, if someone slips and falls under most circumstances they have a high probability of minor injury (e.g., bruising), a modest but lower likelihood of serious harm (e.g., broken bones), and a slight (but real) risk of fatality (e.g., a severe head injury). In these instances, if falling is the result of a spill, then cleaning it up nicely demonstrates the Safety Triangle in action.

We found a similar result for a major company that tracks driving records of its fleet employees. The highest occurrences of vehicular incidents were the result of “at fault” driver distractions but fortunately, only a small percentage of the time did it lead to serious injury and in no instances had it resulted in a fatality. Reducing driver distractions provided an excellent example of where the Safety Triangle approach reduced numerous minor incidents and rarer serious injuries.

Nonetheless, several customers have come forward with skepticism about the efficacy of focusing their efforts on a traditional safety hierarchy. Specifically, it is not the distribution of severity of injuries (and possible fatalities) that they question but rather, whether “cleaning up the bottom of the hierarchy” will somehow take care of eliminating the more severe and often fatal incidences at the top. We now have emerging evidence in support of this doubt in some cases.

Indeed, process failures versus personal failures, have little respect for a safety triangle. Events involving what we euphemistically call “machinery behaving badly” (e.g., explosions, overturns, collapses), have a high probability of fatalities for those in the immediate vicinity and a still higher count of individuals injured who are proximal to the event. While the math of many minor injuries, several major injuries, and some fatal injuries may be consistent with the mathematical distribution of a Safety Triangle, the preventative counsel is to double down on recording observations of near misses, unsafe equipment and processes, and unsafe behaviors that can result in serious injury hazards at the top of the hierarchy. By focusing on eliminating these extreme risks, we can also reduce the number of near misses and minor incidences.

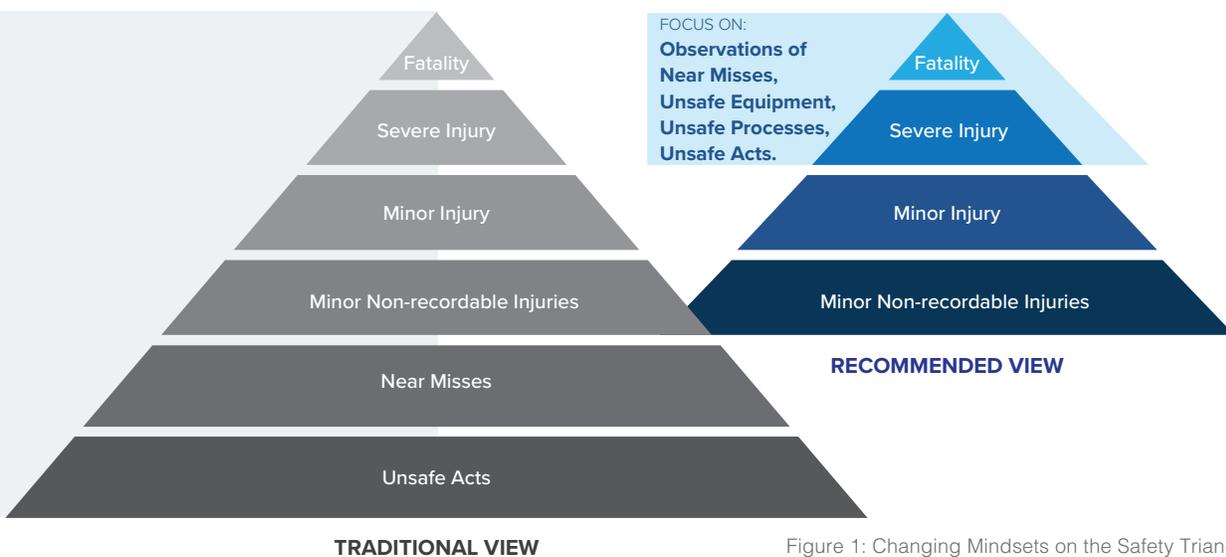


Figure 1: Changing Mindsets on the Safety Triangle

Additionally, many human failures do not conform to this probabilistic hierarchy of injury likelihood. Security protocol lapses in policing, social services and medical facilities, for example, are likely to have significant consequences versus minor ones. Workplaces that involve dangerous jobs that involve high risks such as electrocution, lacerations, extreme temperatures or toxic chemicals do well by eliminating the excessive risks in their work environment before worrying about minor incidences.

Looking over 70 companies where we had several years of data, we came across very infrequent but high impact negative outcomes related to official safety rates that did not conform to the Safety Triangle. Specifically, these were asphyxiation, poisoning and heart attacks. Manage these very severe injuries that often lead to death by removing dangerous, hazardous conditions versus focusing on the sources of minor injuries.

The Power of Leadership

Despite its shortcomings, the Safety Triangle should not be abandoned. It has a major role in preventing simple human error injuries and fatalities as described earlier in our thesis. Most importantly, the Safety Triangle can be a very effective organizational game-changer when there is one critical, intervening variable: leadership. If a CEO is the steward of the Safety Triangle, it works. If a CEO delegates it to a functional manager and relegates the pursuit of Health and Safety to a secondary priority, it is unlikely to drive positive change throughout the organization. Leadership is the defining and causal characteristic here, not the adoption of approaches such as the Safety Triangle itself. The reason is relatively straightforward. If Leaders exhibit that everyone's safety is key to the success of their company, they are likely to instill this value in others as well.

By contrast, if safety efforts are made solely to meet regulatory compliance the outcome may be very different. Seeking the shortest and easiest path to a lower number, such as easing up on reporting and bearing down on minor incidents will jeopardize the functional benefit of the Safety Triangle. There is emerging public evidence that the number of serious injuries may even worsen while minor ones improve in some instances.

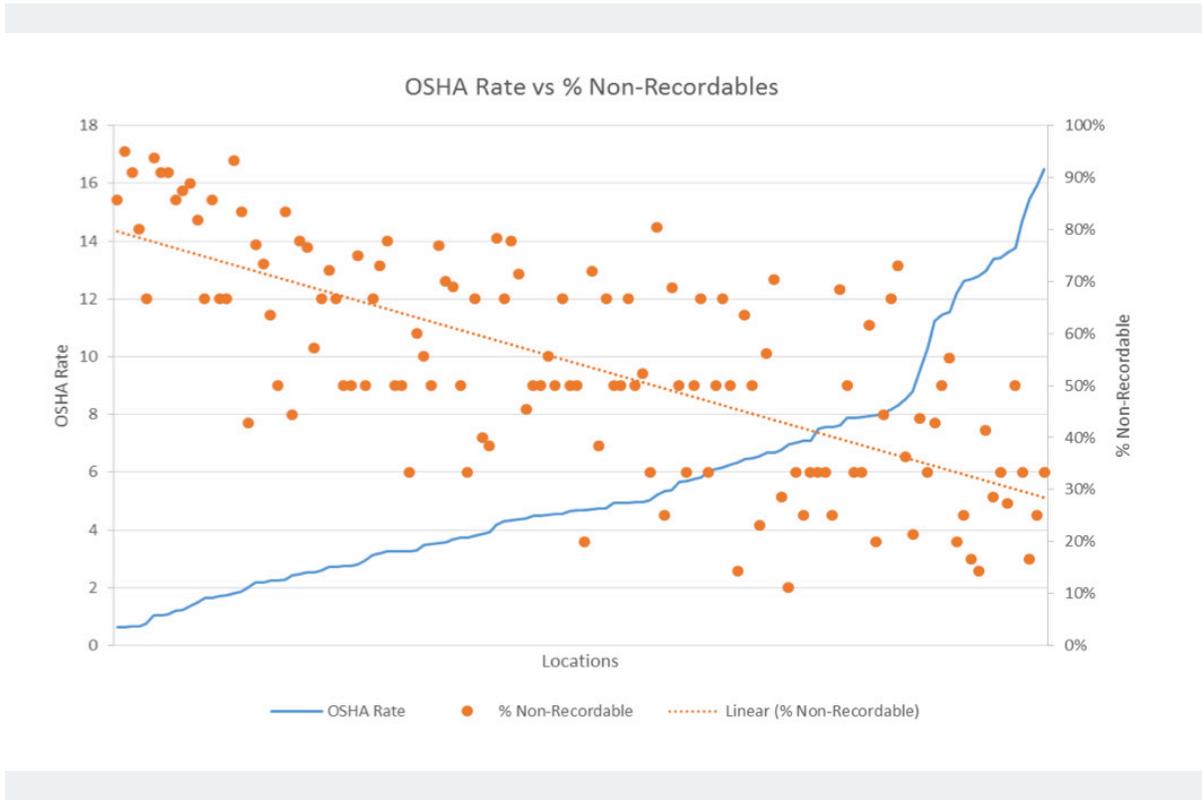
Leading Indicators

Over the past decade, we found ample evidence of companies diligently applying extra resources to reduce workplace injury risk. Included in these efforts are expanded efforts to collect information that would help identify risk factors, such as hazards and unsafe workplace behaviors. Many companies also record extensive information on minor injuries, the so-called "non-recordables" that are not required by government regulators. A few even go so far as to document "near misses."

Collectively, much of this information that we have examined categorizes as "dark data" found by frequency counts of forms completed, user actions and sequence workflows which up until now have been unexamined from an analytics standpoint. The Intelix Data Sciences initiative afforded the opportunity to view this data meaningfully. We sought to understand change within companies over time, as well as to look across companies, on the impact of high versus low volumes of non-recordables, near misses and recorded hazards as they relate to various types of incidences.

Early findings from Intellex’s Data Science initiative clearly demonstrate that high amounts of non-regulated data are in and of themselves, highly predictive of reductions in occupational injury. This evidence held for the decline of both minor and major incidences and became more pronounced for sub-groups. For example, we found evidence looking across locations in one company that increases in the non-recordable documentation were associated with a decrease in workplace injury, by a factor of 10 to 1. We found further evidence from the aggregation of 1000 companies’ data that the small number of companies who go the extra distance of recording “near misses” had occupational safety ratings up to 3 times better than those that did not.

Figure 2: OSHA Rate vs % Non-Recordables



When we consider what companies must do for regulatory reasons versus what they desire to do for their employees’ well-being, our first evidence is very clear that companies who “go the extra distance” make greater gains in safety. The adage that character is what we do when no one is watching seems apropos here.

While the notion of “going the extra distance” has appeal, it was not initially clear why efforts to capture small non-recordable incidents would help to reduce more serious incidences reported to regulatory government agencies. What we are initially finding from these non-recordable incidences has been revealing.

We found many instances where companies keep records of employee “pain,” and these proved to be an excellent predictive contributor of occupational safety ratings. Current complaints of pain tell us a lot about future occupational safety and wellness outcomes. Across the database of companies that we analyzed, young workers in their first year on the job suffer disproportionately higher rates of pain, particularly in their hands. Furthermore, we knew that not all injuries and fatalities occur in a quick twist of bad fortune or poor judgment. Some occur slowly and progressively. Poor ergonomics, socially toxic work environments, and poorly managed worksites can all lead to serious injuries of the body and mind that eventually take their toll. If a condition is deteriorative over time or has a substantial lag between occurrence and symptomatology, it often does not get recorded as a workplace injury. They will show up as recordings of pain, and although these are not a complete proxy for these deteriorative conditions, they do add depth to our understanding of them.

Overall, what our findings suggest is that companies need to increase their collection of both non-recordable and their overall behavioral reporting of near misses, unsafe observations, and findings in inspections/audits before they see a decrease in injury reporting.

Simple demographics also contribute to an ability to predict safety, particularly the composition of workers at locations. The percentage of new employees and, separately, of contractors on a site both contribute independently to less safety. By contrast, two factors driving site safety are a larger size and a greater ratio of supervisors to workers. In workplaces that do not adjust for these circumstances, by proper planning, our findings indicate that more injuries occur.

Lastly, we found that successful avoidance of injuries comes, in part, from looking at variation within companies. How is it that under the same regulatory scrutiny, similar work conditions, and consistent corporate governance some work sites have no workplace injuries while others suffer unconscionably high ones? In some instances, we find over 10x differences in occupational safety between high and low performing locations within the same company. Companies would do well to focus more clearly on internal consistency versus a one-sided obsession with lowering occupational safety ratings. Further support of this approach is our additional finding that a location’s performance in one year contributes to its prediction on its safety performance the year after. As Intalex continues to build out its Decision Sciences practice, we are observing that companies with high occupational safety ratings are consistently inconsistent.

The Health & Safety Maturity Curve

The first stage of tackling the risk of occupational injury seriously involves changing the mindset of companies fixated on Regulatory Compliance, documenting and reporting what is necessary. The easiest route to improvement for many enterprises is to focus on the bottom of the hierarchy where most incidences exist, and that necessarily form the bulk of an Occupational Safety and Health (OSH) rate.

Companies stuck at this level of Health & Safety maturity provide an excellent, but unfortunate, example of how a well-intentioned - but over-simplified - Safety Triangle may lead to a fixation on reducing minor incidences in the belief that the most severe ones would follow suit. From an analytics perspective, there is little to be learned from companies at this initial stage. Overall, at this Stage of maturity, the data captured, analyzed and shared is mostly descriptive in nature.

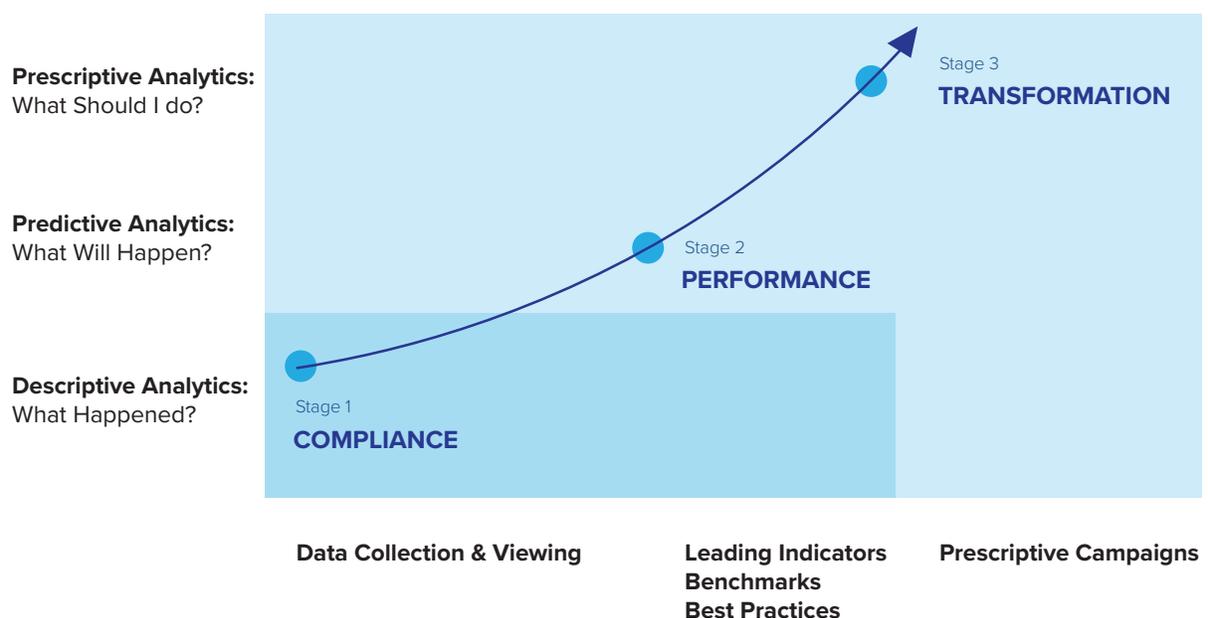
Examining records of fatalities and major incidents alone answers questions of “what happened,” but without documented knowledge of what precedes the events, we offer few insights. This reality explains why minor incidents can drop while major ones and fatalities remain stubbornly fixed.

One steps up this maturity curve, and we find companies that are highly focused on safety through a performance orientation. These companies approach occupational safety by looking at Leading Indicators. With this method, predictive analytics comes into play, and we can begin asking questions of “what will happen” to prevent future events. Much of the Health & Safety academic literature supports this approach, demarking leading versus lagging indicators. Intelix’s Data Science findings offer some challenge to this method as a complete view, with econometric analysis proving useful. Economic forecasting provides the notion of leading (prior-event), coincident and lagging (post-event) indicators.

Prior events like documentation of hazards and unsafe behaviors, near misses and non-recordables are enormously helpful for predicting and avoiding serious incidents. The team’s initial findings are beginning to help us understand the timing sequences here, including a three-month statistical lag for one company that explains the impact of increases in non-recordables on decreases in injury rates. Education and training also clearly fall into this category. With predictive analytics at play, we can answer the question of “what will likely happen” with data-driven insights on Best Practices and importantly, the Benchmarks we are developing on Health and Safety.

Coincident indicators, including documented hazards that occurred at the time of the event, shed a clinical light and are necessary and helpful in the diagnosis of individual incidents. For serious injuries and certainly when fatalities occur, they can be the catalyst for policy and procedure changes within companies.

Figure 3: Intelix Health & Safety Maturity Curve



Lagging indicators occur after the event, and while not predictive, do allow us to measure the toll. In Health & Safety, financial costs and organizational disruption follow death and serious injury similar to how in economics, unemployment rates and social dislocation follow the occurrence of an economic shock that begins a recession. While not predictive, these lagging indicators are important to measure, including as reinforcement for what to invest in proactively to avoid occurrences in the future.

The top of the maturity curve is Transformational Leadership. What we are learning from examining the small number of companies that have made it to this stage is that they are using occupational safety as a strategic differentiator. They recruit, train, recognize, reward, promote and reinforce throughout their culture the need for zero serious accidents and fatalities. They understand clearly the difference between what precedes, coincides and follows serious accidents. With this knowledge at hand, we can begin creating prescriptive campaigns, answering questions of “what should I do?” with data-driven answers that will prevent injury and fatality.

This direction comes from the top of the organization. Most importantly, every worker and even contractor within these transformational companies are both accountable and empowered to act in safety promotion.

Five Data Science Considerations for Health & Safety

1. Measure and Predict Success, Not Just Failure

We have found many companies and many locations within businesses that are experiencing great success. Understanding the enormous variability in safety ratings we observed, both within and across companies, will prove fruitful. A new hypothesis heartens us that some of our greatest future discoveries will be in figuring out why major injuries and fatalities are not occurring at some workplaces despite the dangerous work involved.

Rather than just trying to build predictive equations on rare events, we believe Data Science can borrow from Employee Engagement approaches that study the great managers who achieve both high productivity and high safety ratings to determine their keys to success. We need to avoid the clinical fallacy that comes from studying only the prevention and remediation of failure. Indeed, we can take lessons here from several disciplines - clinical medicine, education, psychology, organizational development – and know that we learn something quite different from studying and predicting long-term success. Companies can use data science to understand the underlying reasons for better worker safety in some locations versus others with similar conditions and circumstances.

2. Build Statistical Competence for Improving Safety

Occupational safety is quite difficult to statistically study because the favorable outcome is an event that has not occurred. It is what actuaries call a “censored” event and predicting success means forecasting an event not to occur or one that is anomalous and rare.

We have found econometric analyses helpful that presuppose leading, coincident and lagging indicators. These have been useful in modeling lag effects on leading indicators in predicting poor safety outcomes. In addition to traditional linear models, Time-to-Event analyses may prove helpful here, particularly when looking to understand and optimize the quality, quantity and methods of training needed to prevent injury and death.

Most importantly, we believe that statistical reasoning and an understanding of underlying probabilities can help create safer workplaces. Our analytical philosophy is that we view the future as not fixed but rather as having a range of likely outcomes across a probability distribution. The question we are answering is not: “When and where will an accident and injury occur?” but rather “How do we drastically increase the odds that we will keep everyone safe?”

We can build on the expertise and prior numbers (including in this case previous injury and fatality rates arising in various industries, various internal and external data to refine predictions of the future as new information arrives. These straightforward notions rely on Bayesian statistics, and not coincidentally; this is the internal name (“Bayes Analytics”) the Data Science team took from the onset when forming a team.

With this straightforward statistical thinking at hand, we believe we can accomplish a few important outcomes through our mathematical modeling. We can:

- a) guide companies to become more confident (but never overly confident) that they can increase their safety success;
- b) reduce risk, which is the probability of a future event multiplied by the consequence of that event; and perhaps most importantly,
- c) reduce risky behavior and risky processes, countering the reinforcement that happens every time individuals and companies get lucky when taking unnecessary gambles on human life and limbs.

3. Go the Extra Mile

Intelex’s Data Science efforts have validated several leading indicators as key elements of an overall approach to Safety that applies across an enterprise. These include the categories of engagement, training, inspections & audits, incidents & near misses, and the corrective actions taken. Undoubtedly this is not an exhaustive list of all leading indicators that may prove helpful to an organization. However, of the many variables that we pragmatically had access to, these consistently made a substantial contribution to safety outcomes across all companies.

In some cases, companies diligently doing more of the same (e.g., more training) achieve diminishing returns on these investments. By contrast, we found a handful of enterprises who tracked “near misses,” and the positive difference in safety levels this new approach made to these companies was astounding. The positive difference this newly adopted approach made to these enterprises were amazing. Coordinating an ability for every employee and contractor to document hazards and near misses, without fear of reprisals, stands out as a great initiative with potential for achieving safety success.

4. Lead from the Top, Empower from the Bottom

No matter the effort taken, what is critical to success is having a Safety Culture led from the very top of the enterprise. Leadership, training, and accountability must come from the upper part of the organization. At the same time, our ongoing research speaks to an urgent need to get safety communication into every worker's hand, particularly those who suffer disproportionate likelihood of injury. These include new workers, along with contractors and employees without much supervision. The key to communication, of course, is that it involves a two-way dialogue. Observing, reporting, and supporting each other's safety first must originate from the bottom.

Mobile technology properly thought through and deployed will undoubtedly help make this communication necessity a reality. Consider a grass roots company effort in which you encourage all your employees - not just your safety engineers - with finding the risky behaviors and unchecked hazards that can lead to death, serious injury and minor accidents in that order of importance. Importantly, be sure to have diligent systems in place to regularly assess the risk of process failures that can result in machines behaving badly versus people doing so. In both instances, diligently record near misses. Document and analyze non-recordable minor injuries, particularly specific complaints of pain. Everyone staying on guard to keep each other safe will undoubtedly clean up many of the minor incidences that occur while preventing the major ones.

5. Be Transformational

Overall, navigating the business landscape to bring about this desired change requires new thinking. Adopting a Health and Safety Maturity Curve with Transformational leadership as the goal is the real key to success. Regulators have necessarily required that companies not make reducing OSH rates one of their KPIs out of fear that it will cause under-reporting and create adverse behaviors such as businesses trying to "game" a lower number. Appreciating this unintended (but not unanticipated) consequence, we wholeheartedly agree and so are building out a Safety Success Benchmark. We believe that while companies need to continue their efforts to reducing occupational safety incidences, transformational efforts should be on predicting and pursuing Safety Success.

We are encouraged by our early findings as they shed new light on the age-old problems of workplace safety. The promise of Big Data is in finding solutions to simple but vexing problems that up until now have eluded answers. What got us to where we are with improved safety will not be what gets us over the finish line. To achieve this goal, we need breakthrough data-driven insights that drive new solutions.

About Intelex

With more than 1,000 clients and 1 million users, Intelex Technologies Inc. is a global leader in Environmental, Health, Safety, and Quality (EHSQ) management software. Since 1992 our scalable, cloud-based software has helped clients across industries improve business performance, mitigate organization-wide risk, and ensure compliance, improve operational performance, and transform company culture. We provide a user-friendly experience that simplifies and centralizes EHSQ data collection and processes while making it easy to identify and report on the metrics that matter.

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