Predictive Analytics in Workplace Safety:
Four 'Safety Truths' that Reduce Workplace Injuries

A Predictive Solutions White Paper

Predictive SOLUTIONS
AN INDUSTRIAL SCIENTIFIC COMPANY

Many industries and business functions are taking advantage of their "big data" sets by performing advanced analytics to make predictions about the future. When applied correctly, predictive analytics allows leaders to gain deep insight into their business and deploy their scarce resources in an optimal way. Advanced and predictive analytics have revolutionized many industries, from biotechnology and mapping of the genome to banking and market research, and is the foundation of Internet search engines such as Google search.

Predictive analytics is now also available to safety professionals to predict and prevent workplace injuries. This white paper reviews recent results from pioneering research in the development of these powerful safety prediction models.

It also outlines the safety inspection data used to fuel the predictive models (leading indicators), and why this type of data is preferred over other safety data (lagging indicators). Finally, this paper describes the actionable insights identified through this research, distilled down to four truths about safety, or "Safety Truths," that drive the predictive models and form the basis of injury prevention activities.

The results of this research, applied to workplace safety, brings us one step closer to the vision many of us share of sending every employee home safe, every day. After all, if workplace injuries can be predicted, they can be prevented.

Can workplace injuries really be predicted?

The simple answer is yes, workplace injuries and safety incidents[1] can be predicted before they happen. This has been confirmed by research conducted by teams from Predictive Solutions Corporation and Carnegie Mellon University (CMU) – the same CMU team that helped develop the Watson supercomputer that originally gained fame by beating the top "Jeopardy" champions and has since been applied to helping doctors diagnose rare and complicated diseases[2]. Using a subset of Predictive Solutions' data set of over 112 million safety observations and their associated safety incidents recorded from over 15,000 individual worksites[3], the researchers proved that workplace incidents can indeed be predicted before they happen with high levels of accuracy. They also found that the safety inspection and observation data from these worksites was a strong predictor of future incidents. The researchers developed a number of predictive models with accuracy levels between 80 and 97% in predicting injuries at actual worksites. The research also found a high degree of correlation – r-squared as high as 0.75[4] – between predicted and actual

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1 The terms "workplace incident" and "workplace injury" will be used interchangeably throughout this paper. As will terms like "safety inspection," "safety audit," and "safety observation."

2 http://money.cnn.com/2011/09/12/technology/ibm_watson_health_care/index.htm

3 Predictive Solutions' data set is compiled directly by its customers in numerous industries through standard safety inspections, safety audits, safety observations, and other leading indicator and hazard analysis data collection programs including Job Safety Analysis (JSA) audits and safety risk assessments conducted BEFORE safety incidents and injuries occur. This data is collected in both Behavior-Based Safety (BBS) as, well as conditions or compliance-based safety and risk assessment programs. The specific studies referenced in this paper included data from 250 worksites across a four-year period.

4 For more information on the use of r-squared values, visit this website http://en.wikipedia.org/wiki/Coefficient_of_determination

incidents. As an example, Figure 1 shows the comparison of the actual incidents that occurred at one of the worksites with the predictions made by a model developed in the study.

Figure 1 – Correlation of Predicted Versus Actual Incidents at a Worksite
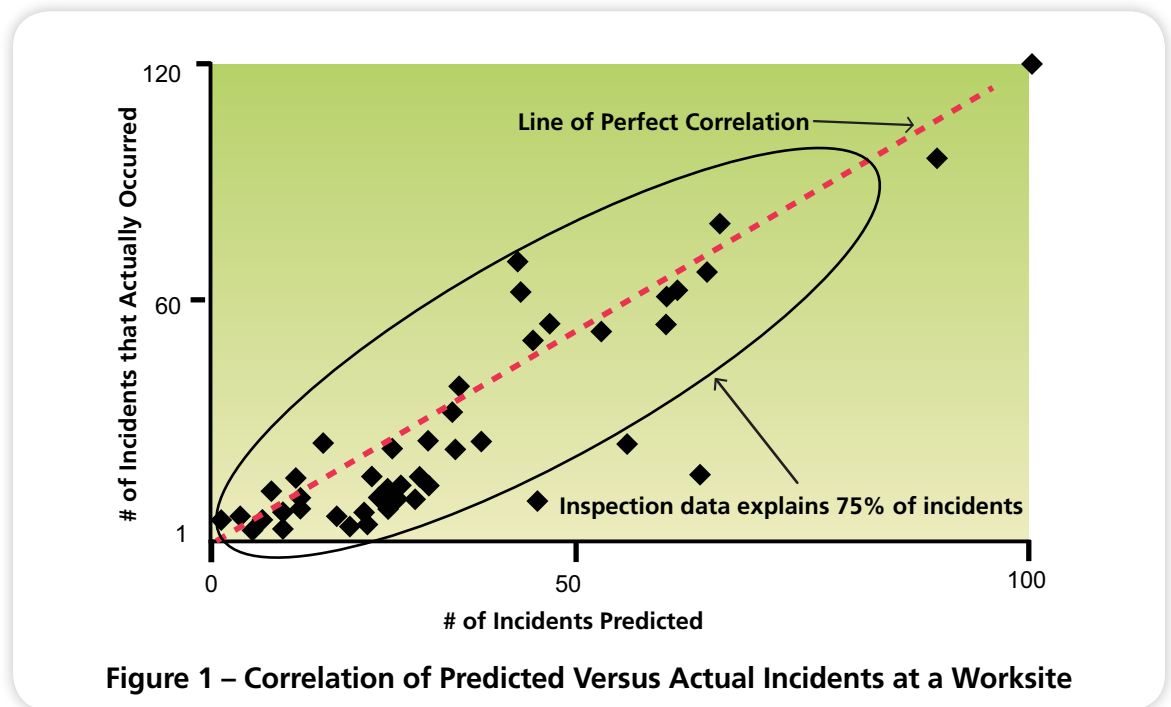
Once it was determined that predictive models could accurately predict workplace incidents, the next step was to identify factors that influence incident levels and what steps organizations can take to optimize their injury prevention programs and ensure employee safety. To answer both of these questions, the researchers turned to the safety inspection data that the predictive models were based on.

Proactive safety inspections are better than reactive incident investigations

Safety inspections are the cornerstone of an effective safety and risk management program. Just as we take measurements of temperature, wind speed, pressure, humidity, etc. over time to arrive at a weather forecast, safety inspections provide the raw data needed to drive the prediction of workplace injuries and safety incidents.

While it is true that historic incident data can also reasonably predict future incident rates, relying on incident data for injury prevention has three major flaws.

First, it is expensive. The Occupational Safety and Health Administration (OSHA) estimates that the direct cost of a recordable incident is $7,000 and a workplace fatality is $910,000[5]. Other industry experts put the indirect costs at three times those amounts[6]. Can companies really afford to rely on such costly occurrences just to get access to data that can help reduce their risk in the future?

5 http://www.osha.gov/SLTC/etools/safetyhealth/mod1_estimating_costs.html

6 http://www.safetymanagementgroup.com/injury-cost-calculator.aspx

Second, waiting for incidents to occur before preventing new ones sends a very chilling message to employees about the company's safety culture. To put it bluntly, leaders are essentially saying, "Joe, I am going to wait until your arm gets severed in our production line before I figure out how to ensure Susan doesn't suffer the same fate. In the meantime, stay safe, and keep that production line moving…we have profit goals to hit!" If leaders are trying to drive both a strong safety culture as well as productivity, this is not an acceptable option.

Finally, and most relevant to those who are experiencing measurable improvements in their injury prevention programs, companies simply run out of incident data points to analyze and learn from. If a company succeeds in driving their incidents down to just a few, or even zero, are they truly safe? How do they know their rates will stay low if they have few or no data points to analyze? There are numerous examples of companies and worksites who one day are celebrating millions of work hours without an incident, but the very next day experience a significant safety incident.[7]

Once a company reduces its incident rate to a low level, they run out of incident data to analyze and have to turn to other data points, like safety inspections and observations, to ensure continued low incident rates. For example, one company in the CMU study lowered its total incidents by 95.3% from 2009 to 2010, resulting in just 20 lagging indicator (incident) data points to analyze. At the same time in 2010, it recorded 8,215 leading indicator (safety inspection) data points to analyze. As they became safer, the lagging data just wasn't sufficient to provide relevant and continuous learning opportunities. This company has now transformed the basis of its injury prevention program from reactive, using lagging indicators such as incidents, to proactive, using leading indicators derived from predictive analytics fueled by a JSA (Job Safety Analysis) inspection checklist program.

Reducing incident rates is always good. However, it does not mean that the work of injury prevention is over – we now need to look more carefully and more widely to prevent a return to high incident rates.

Employing the four Safety Truths

Once it was determined that safety inspection data could drive accurate incident predictions, the researchers went back to the safety inspection data to determine what factors affect incident levels the most. The safety inspection data yielded four key Safety Truths that are not just great predictors of incidents, but also can be deployed toward injury prevention activities once a prediction is made.

◆ Safety Truth #1:
More inspections predict a safer worksite

After detailed analysis of the data, a clear pattern emerged – the higher the volume of inspections, the fewer the number of injuries and incidents. Figure 2 depicts an example of four different worksites and the relationship between number of inspections and recorded incidents over time.

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7 http://online.wsj.com/article/SB10001424052748704307804575234471807539054.html

The trend is unmistakable: *as inspections increase, the reported incidents go down*. In fact, these patterns are very much the norm and repeat themselves over and over in the data.
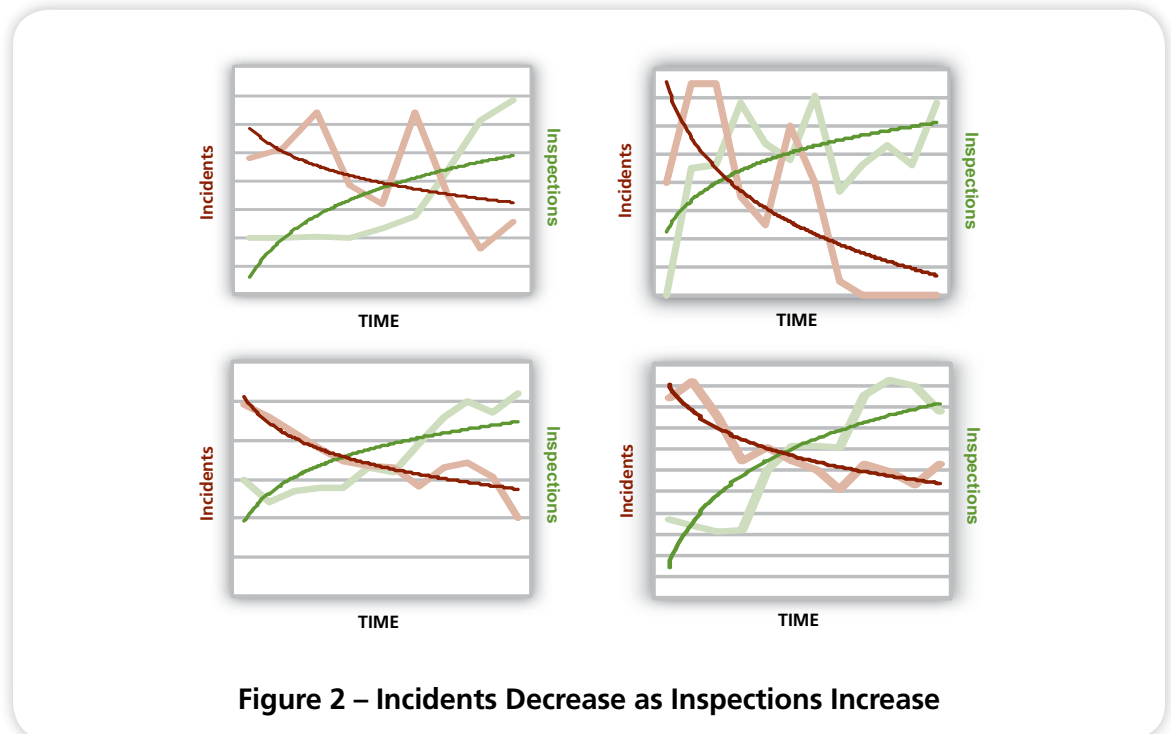

Figure 2 – Incidents Decrease as Inspections Increase

It does not matter what the actual inspections are saying, particularly at the early stages of a safety inspection program, because the greater the number of inspections the better the safety outcome. If your company is experiencing high injury and incident rates, the first step is to simply get onsite with your safety checklist and do more inspections.

◆ Safety Truth #2:
More inspectors, specifically more inspectors outside the safety function, predict a safer worksite

Once an organization starts doing more inspections, the next step is to get more people, and specifically more people outside the safety function, involved. Figure 3 shows the link between incidents and the degree of diversity among people involved in performing inspections. It shows that *the probability of having an incident decreases as the number and diversity of the people performing inspections increases*. Sites that have a high level of participation in the inspection process have a better safety record than sites with a few professional inspectors, even if the total number of inspections performed by the two groups is similar. In other words, having a large number of diverse inspectors doing a few inspections each is better than a few inspectors doing a large number of inspections, even if they are highly trained safety professionals.
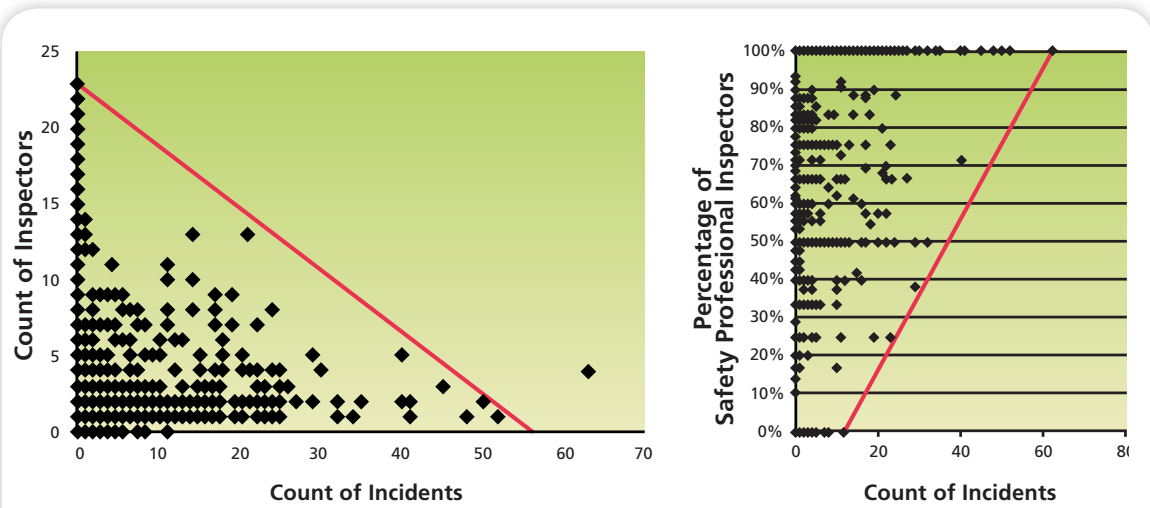
Figure 3 – More Inspectors, and More Diverse Inspectors, Results in Fewer Incidents

If you have increased your number of inspections (Safety Truth #1), but are not seeing improvements in injury prevention, get more people, and people outside of safety, involved in your inspection program.

◆ Safety Truth #3:
Too many "100% safe" inspections predicts an unsafe worksite

While at first it may seem counterintuitive, a high number of inspections with very few, or no, unsafe or at-risk conditions invariably came from some of the most unsafe worksites in the research conducted by the CMU team. While one could interpret the inspections at their face value and assume that the site is safe given low levels of unsafe conditions, this is rarely the case. It turns out even the safest worksites (e.g. EMR[8] well below 1.0) often have inspections that record a moderate level of unsafe observations.
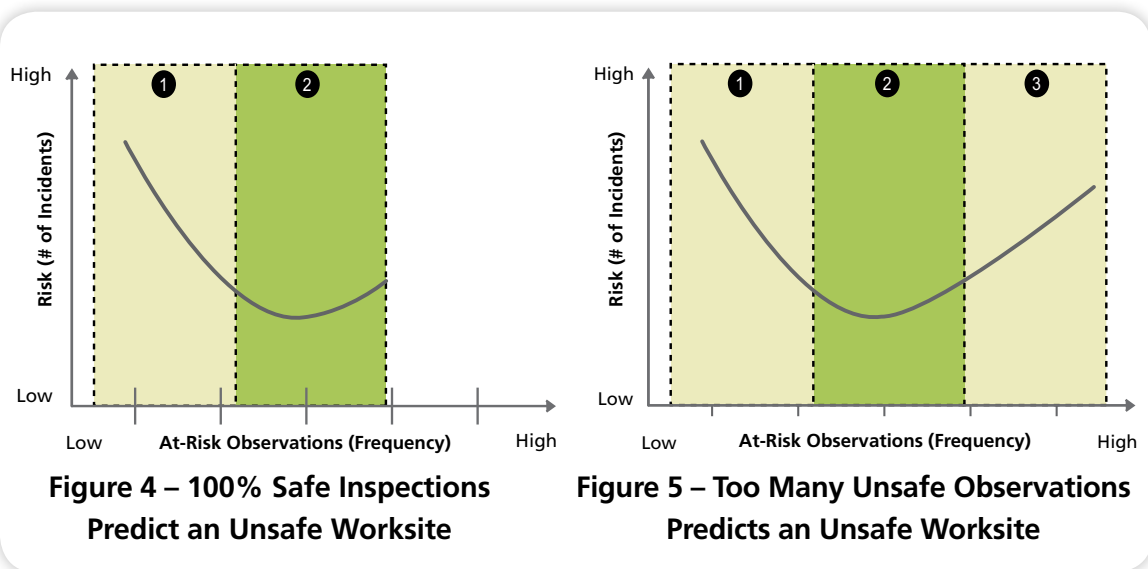
Intuitively it may seem that as worksites improve their safety performance the number of unsafe conditions reported by safety inspections would fall, but what happens in practice is quite different. The proportion of unsafe conditions found remains fairly steady as organizations continue to improve their safety performance. Generally, as the work environment changes, due to new processes, procedures, equipment, employees, etc., new unsafe observations are found that were not evident in the old environment. Or, what was once considered an acceptable condition or behavior is now deemed unsafe based on new information. Inspectors continually become more critical and discerning of conditions and behaviors in the workplace.

If most inspections are returning 100% safe information, your organization may be "flying blind," meaning the worksite is at a higher risk of having an incident, but the inspectors are either not seeing, or reporting, the leading indicator signs of those incidents. Research shows that the safest worksites continually find a certain level of unsafe conditions and behaviors, and then fix them before they

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8 Experience Modifier Rate – see this website for more information on EMR http://en.wikipedia.org/wiki/Experience_modifier

become actual incidents. Figure 4 shows the evolution from the higher risk, or "flying blind," stage (stage #1, in light green) to the lower risk, or "find and resolve," stage (stage #2, in green).

Figure 4 – 100% Safe Inspections Predict an Unsafe Worksite

Figure 5 – Too Many Unsafe Observations Predicts an Unsafe Worksite

If you're still having issues with your injury prevention program, make sure your program not only rewards high levels of inspections (Safety Truth #1), by many and non-safety team members (Safety Truth #2), but also trains for and rewards the reporting of unsafe observations from your safety inspections. The more unsafe observations you get, the more you can resolve before they become actual safety incidents.

◆ Safety Truth #4:

Too many unsafe observations predicts an unsafe worksite

To state the obvious, a persistently high level of unsafe conditions is associated with a high level of incidents. Analysis of the data showed that companies in this group have nearly the same level of risk as those that find virtually no unsafe conditions (the "flying blind" stage outlined in Safety Truth #3 and Figure 4). What often occurs is that a lot of inspections are done (properly adhering to Safety Truth #1) by a large and diverse inspection group (properly adhering to Safety Truth #2) and they find a high level of unsafe conditions and behaviors (thus positively avoiding Safety Truth #3). However, the levels of unsafe observations keep increasing because they are not being resolved. **This can be referred to as the "inaction" stage. In this stage, the inspection program is strong, but the resulting injury prevention activities are not.**

In Figure 5, the chart in Figure 4 is expanded to include this "inaction" stage. In order to move away from this inaction stage (stage #3, in light green) and move back to the area of least risk (stage #2, in green), the worksite must commit to resolving its unsafe conditions and behaviors, which the research shows should drive down the level of future unsafe observations to an acceptable level.

Actual results when the Safety Truths are employed

The research found that worksites that successfully incorporated all four of the Safety Truths had two to three times less incidents. By promoting high levels of inspections, across both safety and non-safety functions, where it was expected that unsafe observations would be continually found and addressed, world-class worksites were able to manage their risk of injuries and stay in stage #2 of Figure 5 – the area of lowest risk.

Conclusion

Workplace safety professionals now have access to cutting-edge advanced and predictive analytics that can predict workplace injuries with high levels of accuracy.

In order to employ predictive analytics in your workplace safety program, you need to fuel the predictive models with data from a robust safety checklist and inspection process, whether it be behavior based or compliance and condition based.

Once the technology predicts where and when injuries will occur, you can use your inspection data to guide your near-term injury prevention activities, and also reduce your risk of future injuries by adhering to the four Safety Truths:

◆ Safety Truth #1:	◆ Safety Truth #2:	◆ Safety Truth #3:	◆ Safety Truth #4:
More inspections predict a safer worksite so make sure your program rewards high levels of inspections	**More inspectors, specifically more inspectors outside the safety function, predict a safer worksite** so include as many people as you can in your safety inspection program and ideally, have more non-safety than safety people in your program	**Too many "100% safe" inspections predicts an unsafe worksite** so train for and reward the reporting of unsafe observations	**Too many unsafe observations predicts an unsafe worksite** so commit the time and resources to fixing the unsafe observations before they cause incidents, avoiding persistent high levels of unsafe observations

By employing this methodology, you can reduce your costs, as well as help ensure that every employee goes home safe every day.

It is unconscionable to employ predictive analytics in industries like banking, market research, and Internet search and advertising, and NOT in workplace safety and risk management. Safety professionals, like their peers in these other industries and functions, can now stop being reactive and start being proactive. We can stop investigating incidents, and start predicting and preventing them. It is the right, and smart, thing to do.

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About Predictive Solutions Corporation

Predictive Solutions Corporation, formerly DBO2, saves lives by predicting workplace injuries. Its software solutions help track, trend and analyze safety related data. They also employ proprietary models that predict the likelihood, frequency and location of workplace injuries using its customers' safety observation data. In addition, Predictive Solutions delivers consulting services that drive culture and process change within organizations to create sustainable safety processes that reduce injuries. With more than 100 million observations and nearly 40,000 reported incidents from more than 15,000 worksites around the world, Predictive Solutions has emerged as an industry leader in predicting injuries before they occur. Predictive Solutions, based in Pittsburgh, Pa., was founded in 2001 and became an Industrial Scientific company in 2008. Its employees, along with those of its parent company, are dedicating their careers to ending death on the job in this century. For more information, visit www.predictivesolutions.com.