Determining Serious Injury and Fatality Exposure Potential

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Over the past several months we have extensively examined a startling fact that has caught the attention of safety and operations leaders; over the past five years serious injuries and fatalities (SIFs) have plateaued or increased while smaller injuries have continuously declined. The pattern is seen to varying degrees at the site level as well as the company and national level and calls some fundamental safety science assumptions into question.

Seven global companies sponsored a study to explore this phenomenon, its implications, and how to address it. The seven companies' combined data was subjected to in-depth qualitative, statistical, and root cause analysis. Leaders from each company formed a team to support the analysis and interpretation of data. Findings from the study identified two primary reasons that reduction in less serious injuries does not necessarily correspond to reduction in SIFs:

1. The causes and correlates of SIFs are often different from those for less serious injuries

2. The potential for serious injury is low for the majority (typically around 80%) of non-SIF injuries.

The issue of potential is important for addressing SIFs. For example, consider the activity of manual lifting. The most common injury resulting from manual lifting is soft tissue injury (sprains and strains), and this exposure is unlikely to cause a fatality. On the other hand, falling from a height of 10 feet clearly has the potential to cause a fatality or life-altering injury, even though that is not always the outcome of such a fall. To impact SIFs, a safety initiative must target the exposures that have SIF potential.

When companies rely solely on recordable injury rates as the primary measure of safety performance (a common practice) they lose sight of crucial data underlying SIFs. Safety initiatives can be directed at exposures with low SIF potential for no other reason than because they occur more frequently. And because the visibility of SIF precursors is lacking, leaders can mistakenly believe that their actions are addressing the likelihood of all injury types.

Understanding and Managing the Issue

As is true with any area of performance, in the prevention of SIFs it is important to be able to measure progress. A performance metric tells us whether we are improving, remaining stagnant, or backsliding in our efforts toward a goal. This in turn tells us whether our current efforts are succeeding, or whether we need to change our approach.

A challenge in measuring progress on SIF prevention is that actual SIF events in any given organization are infrequent. As a result, the measurement of SIF events themselves will involve a very small number of data points, rendering attempts to assess trends and changes in this data in a statistically meaningful way seemingly impossible.

However, as we have already discussed, SIFs occur as a result of exposures that have SIF potential. And whether those potential-laden exposures result in an actual SIF is a matter of luck. That being the case, what we really want to measure is the rate of potential SIFs – both the exposures that resulted in an actual fatality or serious injury plus those that could have but did not. By reducing the rate of potential SIFs we also reduce the opportunity for serious injuries and fatalities to occur. Measuring the rate of potential SIFs tells us whether we are improving and expends the number of data points to a level where we can observe changes and trends.

This presents the challenge of defining an appropriate measure of SIF potential and a method for classifying incidents so we can identify the SIF potentials. The effectiveness of this classification is determined by two key factors:

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1. Agreement and calibration on the definitions of "SIF" and "SIF Exposure Potential."

2. A valid, reliable, and repeatable classification scheme to evaluate incidents for SIF Exposure Potential.

SIF and SIF Exposure Potential Defined

Each organization must define how broadly it wants to define the "serious injury" part of "fatalities and serious injuries." While fatalities refer to work-related fatal injury or illness, "serious injury" can be defined more or less broadly. Two examples follow:

- Example 1: **Serious Injury –** a life-threatening work-related injury or illness. *Life-threatening* is broadly understood to be a case that required immediate life-preserving rescue action, and that if not applied in an immediate fashion, would likely have resulted in the death of that person. These cases usually require the intervention of emergency response personnel to provide life-saving support. Some common examples would include significant blood loss, damage to the brain or spinal cord, use of CPR or AED, chest or abdominal trauma affecting vital organs and serious burns.

- Example 2: **Serious Injury –** a life-threatening *or* life-altering work-related injury or illness. ***Life-threatening*** is broadly understood to be a case that required immediate life-preserving rescue action, and that if not applied in an immediate fashion, would likely have resulted in the death of that person. These cases usually require the intervention of emergency response personnel to provide life-saving support. Some common examples would include significant blood loss, damage to the brain or spinal cord, use of CPR or AED, chest or abdominal trauma affecting vital organs and serious burns. ***Life-altering*** is generally viewed to be a case that resulted in a permanent and significant loss of a major body part or organ function that permanently changes or disables that person's normal life activity. Some examples would include significant head injuries, spinal cord injuries, paralysis, major amputations, catastrophic fractured bones, and serious burns.

How an organization defines SIF is simply a matter of how broadly or narrowly it wants to focus its special emphasis. In any organization efforts will continue to prevent all injuries and illnesses while special emphasis is placed on SIFs. The appropriate breadth of that special emphasis will tend to depend on factors such as the number and types of exposures and incidents experienced.

With respect to defining SIF-Exposure Potential, a case can be said to have SIF Exposure Potential when the incident results in an actual SIF or when the exposure could have reasonably and realistically resulted in a fatality or serious injury outcome had any of the circumstances, factors, or protective measures changed, and there is a sense that luck or chance had a role to play in the severity of the actual outcome. In other words, if the situation was repeated dozens or hundreds of times, is it reasonable to conclude the outcome would eventually be a SIF?

The SIF-Exposure Potential Classification Scheme

At the point the items above are in place, the organization is ready to design a classification schema to reliably evaluate incidents for SIF Exposure Potential. There are two general approaches for these schemas. One is referred to as the ***"Judgment-Based Narrative Review"*** process, and the other is referred to as the ***"Event-Based Decision Tree"*** process.

Judgment-based Narrative Review

The "Judgment-Based Narrative Review" approach relies on professional judgment to assess whether the event could have resulted in a SIF, and uses the accident report narrative to identify and explore the context of the exposure situation to identify those cases with SIF potential. This approach can capture the vast majority of SIF potential events as long as consistent screening is accomplished at the local level. Below are several important steps for effectively implementing a Judgment-Based Narrative Review process.

Begin by conducting calibration exercises to build high inter-rater reliability. A tried and tested approach is to select the group of case assessors (e.g. safety professionals, supervisors, managers) and review the accident investigation narratives of approximately 10-20 reported

incident cases, then posing the question "Does this case have SIF potential – yes or no?" to each member of the group. As each case is reviewed, the group discusses the rationale for each "Yes" or "No" rating, clarifying their respective positions, refining definitions, and building consensus.

Conduct 3-4 rounds of case reviews until the group nears 95% or greater agreement. For example, in one client experience, a team of four reviewers improved their inter-rater reliability by achieving 100% accurate and consensus determination as follows:

- Round One = 16 of 21 cases reviewed

- Round Two = 16 of 19 cases reviewed

- Round Three = 31 of 32 cases reviewed

- Round Four = 70 of 70 cases reviewed

Once raters have been trained for effective and reliable evaluation, the steps they will follow for classifying an incident are to:

1. Read the complete accident narrative to understand the context and circumstances surrounding the accident.

2. Use the agreed-upon definition of "serious injury." The key is to understand the concepts of "life-threatening" or "life-altering" injury or illness.

3. Make a binary Yes/No decision, using the following guidance:

   a. SIF Potential equals "Yes" if one or two of the circumstances/factors could have obviously, easily, reasonably changed, and there is clearly a high probability that the outcome could have become a Serious Injury (by definition) or Fatality, and it is more likely than not that luck or chance prevented it.

   b. Another way to approach this is using a reasonable or practical probability that the event could have resulted in a serious injury or fatality if the event was repeated many times.

Examples of how to apply these criteria are shown in the following table:

INJURY	CASE	DESCRIPTION	SIF POTENTIAL?
Fractured Foot	A	Employee suffered a fractured foot when backed over by a Powered Industrial Truck (PIT) forklift. The PIT operator backed up without looking, and the backup alarm was not functioning. This easily could have been a serious (life-threatening or life-altering) injury or fatality if the employee's full body had been struck and run over.	YES
	B	Employee suffered a fractured foot when they climbed out of a truck cab, missed the bottom rung of the ladder, and dropped 30 inches to the ground. Their foot rolled off a small rock, resulting in a fracture.	NO
Laceration Requiring Sutures	A	A worker cut his finger on the sharp edge of a pipe flange in the machine shop. He was grinding the burrs off the flange end, wearing all necessary PPE. He stopped grinding and removed his glove to feel the edge with his finger to see if the burrs had been successfully removed. The edge was sharper than expected, resulting in a cut to the left index finger that needed two sutures.	NO
	B	A 4-foot by 8-foot by 1-inch steel plate was being moved for installation by two workers using an overhead hoist. The plate shifted unexpectedly and worker #2 tried to steady it with his hand. The plate shifted again, this time pinching worker #2's hand against the steel frame. He sustained a laceration of his right ring finger, which required sutures to close.	YES

Finger Tip Amputation	A	Worker was using a 4 pound hammer to drive an anchor bolt, and struck the tip of their finger, resulting in the amputation of the tip of their thumb.	NO
	B	Worker reached into a rotating paper machine calendar to remove a paper jam. Right index finger was caught in the in-running nip point, the emergency stop was activated, and the calendar reversed, releasing the finger. The only injury sustained was an amputation of the finger tip. Clearly, this event could have resulted in a significantly more serious injury or a fatality.	YES
Wrenched Back	A	Worker was walking across the floor, slipped on grease, caught himself on a railing, and wrenched his back (strained back muscle).	NO
	B	Worker fell from the top of a rail car when his car was struck by another rail car that was being moved into position. The worker fell on top of the tank car, grabbing the guard rail around the dome lid, preventing a fall to the ground. The only injury resulting was some bruising and a strained back muscle. Even though this event was classified as "first-aid", it clearly has high potential for SIF.	YES

Using this approach, there may occasionally be a "gray area" where it is difficult to make a Yes/No decision. For example:

Employee fractured foot while working on a ship deck when he stepped through a large deck/hold opening, and fell four feet landing upright on top of some grain bags. The employee suffered strained leg muscles.

If the individual assessor or assessment team needs more information to make a Yes/No determination, they may need to review to case file, interview people knowledgeable in the incident, or interview the involved parties. The team or assessor could also decide to ask one to three other safety professionals to provide their opinion on the matter, or the team could simply say "cannot decide" and leave it in the gray area. In BST's original SIF research project, this occurred only twice in 457 cases (and was due to lack of complete narrative information about the cases).

One downside to the Judgment-Based Narrative Review approach is that unless every case is reviewed by the same individual or team it is heavily reliant on maintaining high inter-rater reliability and preventing judgment "drift" over time. This approach is best-suited for organizations with a small team of raters who review and classify all incidents on a regular basis, and engage in frequent calibration exercises. Success in using this approach is more likely in those organizations that have control over a few sites, or operate as a single site. Organizations using this approach should recognize

that consistent and accurate classification will be an ongoing challenge, and that turnover in members of the assessment team will need to be managed.

Event-based Decision Tree Classification approach

The second, and preferred, approach uses the characteristics of the incident or near miss to classify a situation as having SIF potential. The benefits of this approach are that (1) it is much less dependent on subjective judgment, so that events can be classified in a consistent manner by different individuals throughout an organization (e.g. at the local level where the incident occurs), and (2) once the system is established classification it is quick and easy.
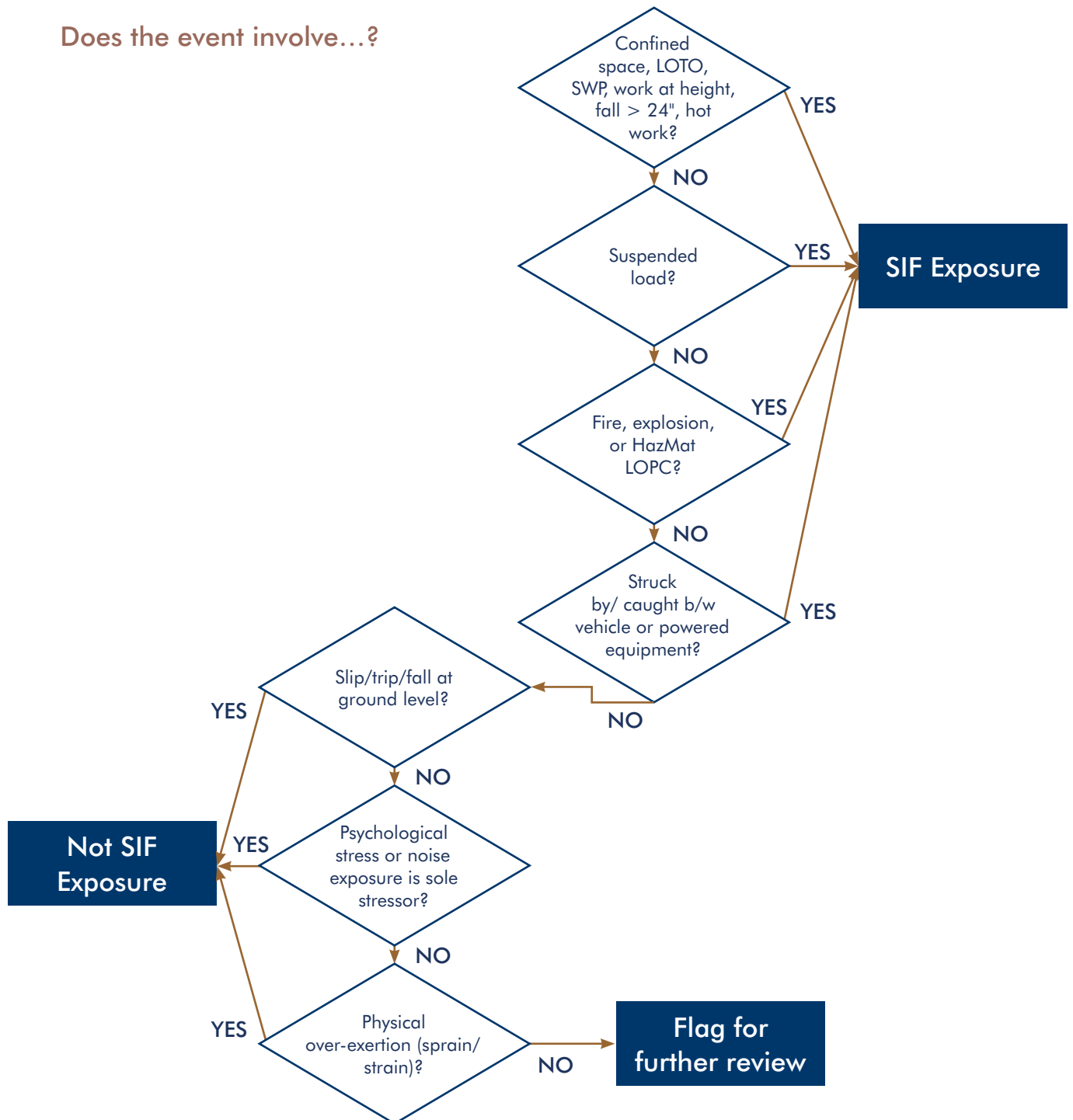
In using the event-based approach we begin by recognizing that there are particular activities which more naturally lend themselves to producing higher proportions of precursor events. Examples of these activities include:

- Operation of mobile equipment and interaction with pedestrians

- Entering confined spaces

- Performing jobs that require lock-out tag-out

- Operations that entail suspended loads

- Working at height

Beginning with a generic SIF classification decision tree (see figure 2), an organization can perform a one-time customization. A small group applies the generic decision tree to the organization's incident experience (injuries, near misses, and process safety events). After identifying the events that decision tree criteria indicate are and are not potential SIFs, we are left with a number of unclassified events. The small group then does a one-time, judgment-based assessment of the unclassified events, and from the ones selected as precursors, modifies the generic decision tree to one customized to the organization's exposures. That customized decision tree can then be used throughout the organization to drive event-based classification of all incidents, providing a SIF precursor metric.

Does the event involve…?

Confined space, LOTO, SWP, work at height, fall > 24", hot work? — **YES** → **SIF Exposure**
— **NO** ↓

Suspended load? — **YES** → **SIF Exposure**
— **NO** ↓

Fire, explosion, or HazMat LOPC? — **YES** → **SIF Exposure**
— **NO** ↓

Struck by/ caught b/w vehicle or powered equipment? — **YES** → **SIF Exposure**
— **NO** →

Slip/trip/fall at ground level? — **YES** → **Not SIF Exposure**
— **NO** ↓

Psychological stress or noise exposure is sole stressor? — **YES** → **Not SIF Exposure**
— **NO** ↓

Physical over-exertion (sprain/ strain)? — **YES** → **Not SIF Exposure**
— **NO** → **Flag for further review**

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With this approach the decisions on events as they occur are based on the objective criteria of the decision tree, ensuring consistency. The tree can be applied locally, so classification/identification of potential SIFs can occur in real time, facilitating reporting of the SIF metric. This approach is also quick, as it avoids case-by-case discussion in the classification process. By flagging those non-SIF potential events that failed to meet any of the inclusion or exclusion criteria of the decision tree, the system can also be self-improving. The original small group that refined the tree can meet annually (or at some desired interval) to examine those cases for characteristics that might result in refinement of the decision tree.

While some might argue that this approach risks missing the occasional SIF potential event that has never been seen before, having a simple classification process that will be 90% or more accurate and eliminates inconsistency overcomes those objections for most people.

Conclusion

Whichever method is used for classifying potential SIFs, a key first step in reducing fatalities and serious injuries is establishing and reporting on a metric for exposure to these incidents. When an organization supplements its reporting of recordable and lost time injuries with a rate of SIF exposure events, there is a basis for assessing progress and detecting increases in risk. Only when there is visibility of the issue can real progress be made toward reducing SIF incidents.

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