Identifying, Controlling and Eliminating Serious Injury and Fatalities

Dr. Dominic Cooper

Since the advent of Heinrich's (1931) Injury Pyramid, it has been asserted there is a *predictive* relationship between each of the severity levels (See Figure 1). This has led to a truism that the frequency and types of minor injuries at the bottom of the pyramid, predict serious injuries at the top of the pyramid (serious injuries are classed as life-threatening, life-altering or longer-term temporary disabilities).

This has led to the notion that by controlling the causes behind these minor injuries (i.e. focusing on events at the base of the pyramid), serious injuries and fatalities will also be controlled). Although long-term injury incident rates have been reducing, this assertion has been questioned over the past two decades by a number of scholars (Peterson, 1989; Hale, 2002; Manuele, 2008; Krause, 2012). In large part this has been prompted by large scale industrial disasters (e.g. Piper Alpha, Buncefield, Texas City, Macondo) occurring on sites with very low personal injury rates.

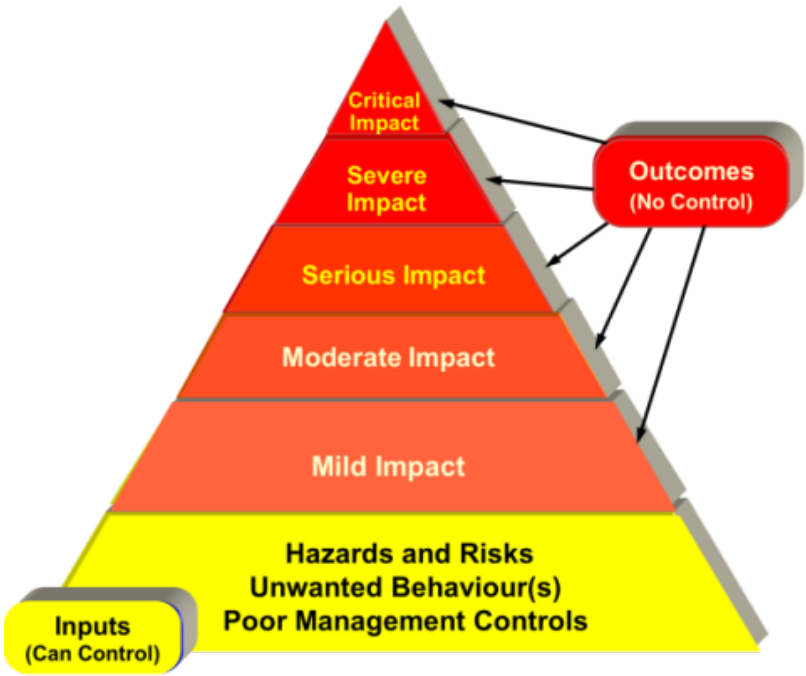

Figure 1: Incident Pyramid

Actual incident data (see Figure 2) downloaded from the British Health & Safety Executive (HSE) website covering the years 1986-2013 shows that

while the number of 3-day plus injuries has decreased by around 60%, there has been a trend across all industries for serious injury and fatality (SIF) statistics to remain fairly static (no data was available for less than 3-day injuries). This shows that existing control strategies are not reducing very serious injuries at the same rate as less severe injuries, and that something new is required and/or existing strategies need tightening.

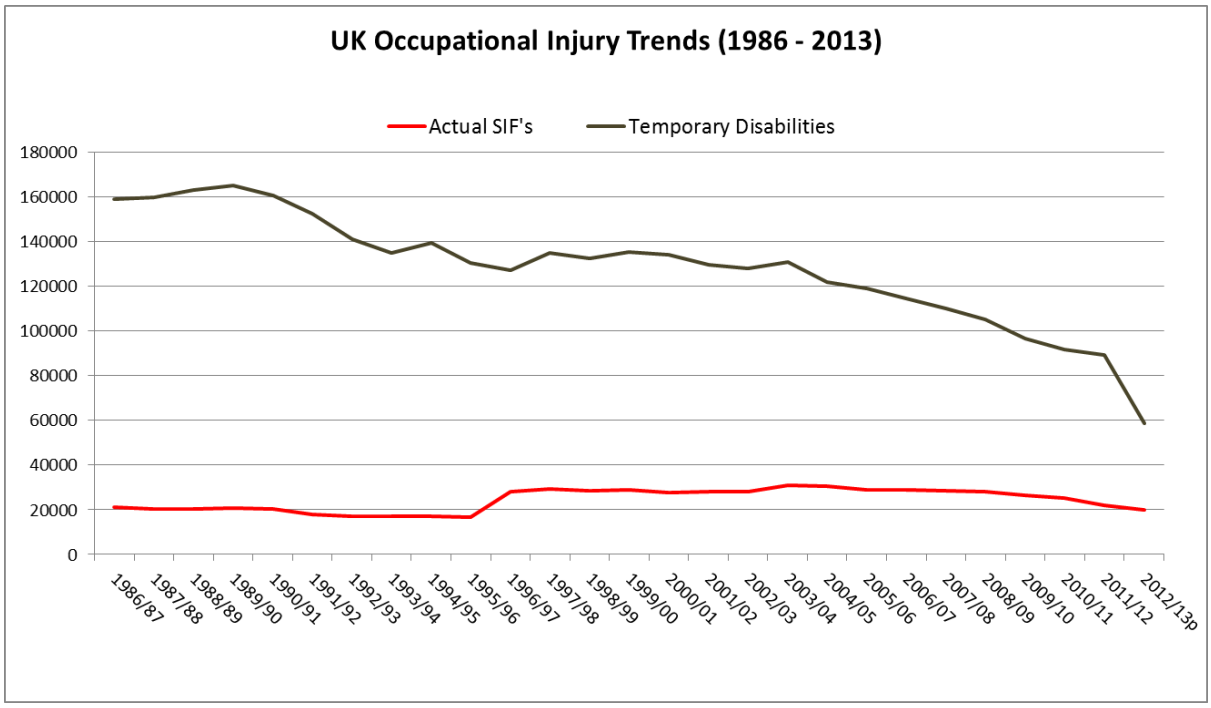

Figure 2: UK Long-term Occupational Injury Trends Reported to the HSE (1986-2013)

It is important to recognise that frequency reduction does not necessarily mean equivalent reductions in the severity of incidents, as it is difficult, if not impossible, to control the severity of an incident. The failed blind shear rams at the Gulf of Mexico's Macando incident provides one example, where 11 people lost their lives, the infrastructure was destroyed, and the environment was significantly impacted.

Part of the problem may be that a company cannot make meaningful predictions about where the next potential SIF may come from as they do not experience enough high potential/low frequency incidents to make meaningful conclusions.

As stated by Andrew Hale (2002), "major incidents can sometimes be predicted by minor incidents, but not always; there are always precursor signals (close-calls and deviations) of major incidents; and not all minor incidents could result in major incidents. Many SIFs are unique and singular events, having multiple and complex causal factors that may have organisational, technical, operational systems or cultural origins".

Recent work by Mercer ORC HSE Networks showed that about 20% of all

incidents they examined were potential SIF's. They demonstrated that [1] focusing injury reduction strategies *solely* at the inputs at the bottom of the Injury Pyramid will not *proportionally* reduce the number of potential SIF's; [2] because the causes and correlates for potential SIF's are different than non-SIF injuries, different control strategies are required; [3] in practice this means [a] being able to identify, understand and control the precursors of all potential SIF Events; [b] using a potential SIF metric to track their prevalence (i.e. Number of potential SIF's / Man-hours Worked).

Philosophical and Practical Implications

Implementing a potential SIF control program is a big undertaking as it means "raising the bar" to help a company achieve world-class safety performance. It requires a change in philosophy from solely focusing on those events that led to an actual injury (*a reactive response*) to examining events that *potentially* could have led to an SIF - *a proactive response*.

In turn, every potential SIF Event should trigger a Root Cause Analysis (RCA) which has significant time and cost implications. Currently, most companies use RCA when an *actual* SIF has taken place, but tend not to allocate the same resources to those events that experienced a minor injury, but had the *potential* to be much more serious.

An SIF control program implies and pre-supposes that any Event, regardless of the actual severity of injury will be Root Cause Analysed if it has *the potential to lead to a life –threatening or life-altering event*. In sum, this means an event's *potential consequence(s)* should be the primary driver for the prioritization of corrective and preventative action. This should include:

a. Allocation of sufficient resources to mitigate the precursors, exposure activities and underlying cultural contributors
b. In-depth investigation of every potential SIF
c. Thorough Root Cause Analysis of every potential SIF
d. Lessons Learned dissemination and execution,
e. Tracking of recommendations, and Corrective & Preventative Action (CAPA) completion
f. Follow-up and review of the effectiveness of Corrective and Preventive Actions

Given that this has time, cost, and resource implications, it is vital that there be agreement of the definitions associated with an SIF program to maximise the program's value.

Categorisation Processes

The best means of approaching a potential SIF analysis is to provide a very clear structure to enhance the consistency by which events are allocated into 'Precursor Situations', 'Exposure Activities' and 'Underlying Cultural Contributors'. It is highly recommended that companies create and train a team of Internal Subject Matter Experts (SMEs) to facilitate the consistent classification of potential SIF's.

There also needs to be a very clear understanding by the SIF project team members of the Severity Levels, Precursor Situations, Exposure Activities and Underlying Cultural Contributors to enhance consistency when assigning each event into its appropriate categorisation. To help overcome any problems, it is worth adopting the ExxonMobil approach of 'Feasible-but-Reasonable scenario' and specify the precise type of *potential injury* it is believed would result from the event to facilitate justification and consistency. It is also important to ensure each case is peer reviewed: this facilitates the correct classification of those events that are unclear, until agreement is reached.

Define a Severity Scale

To determine whether an Event is a *Potential* SIF or not, it makes sense to define and use a Severity Scale that can be consistently understood by anyone. Luckily this has been done for us by the Massachusetts Department of Public Health (2005; 2007), who developed and make use of standardised severity definitions in medical settings.

Adopted by the author and others (e.g. Mercer Network) exploring SIF control programs, it contains a 5-Level potential SIF Severity Scale ranging from most serious to least, as follows: Life-Threatening (Level-5); Life-Altering (Level-4); Temporary Disability and work days lost (Level-3); Restricted work activity / temporary change of job duties (Level-2); and First-aid treatment and immediate return to work (Level-1).

Usually, Level 4 & 5 events are treated as Potential SIF's. In my view, it is also worth including Level 3 as *potential* SIF's simply because a Temporary Disability could easily exceed 30 days for recovery (e.g. A broken bone may take many months to heal before the Injured Party returns to work). Levels 1 & 2 are *not* treated as potential SIF's. The detailed Severity Scale with appropriate examples is presented in Table 1.

Table 1: Incident Severity Scale

Potential SIF	Severity Level	Actual Severity	Event Type	Potential Outcomes
Yes	5	Critical	Life-Threatening	Uncertain survival - Injury or illness which could lead to the death of the affected individual.
Yes	4	Severe	Life-Altering	Probable survival - Permanent or long-term impairment or loss of use of an internal organ, body function, or body part.
Yes	3	Serious	Temporary Disability	Not life–threatening - Traumatic injury causing limited or no use of fingers, hands, extremities, fractures, avulsion, burns or major lacerations.
No	2	Moderate	Restricted Work	Moderate Severity Event - Lacerations, dislocations, strains, burns, soft tissue injuries, limited use of hand or fingers.
No	1	Mild	First-Aid, with immediate return to work	Mild Severity event - splinters, foreign body in eye, eye burns, or scratches.

Using specific injury examples (e.g. Head Injury, Chemical Burn, etc.) for each of the severity levels often helps managers and supervisors be consistent when completing incident reports to determine if an event is a potential SIF or not.

Identify and Define Pre-Cursor Situations

An SIF precursor has been defined as "*A combination of hazard(s) and underlying human factors and organizational or managerial deficiencies that if left unaddressed can result in a fatal or serious injury*" (Wachter & Ferguson, 2013). In other words, an SIF precursor refers to a high-risk situation in which management controls are either absent, ineffective, or not complied with, and which will result in an SIF if allowed to continue (Krause & Murray, 2012).

According to the evidence (Manuele, 2008; Krause, 2012) most potential SIF's are disproportionately related to unusual or 'non-routine' precursor situations. (e.g. Process Upsets —where normal operations become abnormal). The author defines a non-routine precursor situation as "a *situation not generally encountered during the course of normal operations*". The Mercer study found a high proportion of precursor events for the following non-routine situations:

- Process instability
- Significant process upsets
- Unexpected maintenance
- Unexpected changes
- High potential energy jobs
- Emergency shutdown procedures
- Unusual/Non-routine work

It is important to recognise that both routine and non-routine precursor situations carry significant SIF risks. For example, when analysing two years of Contractor incidents, the author found 90% of potential SIF's were related to routine, everyday situations. The percentage of actual SIF's, however, was higher for non-routine events (59%) than routine events (34%).

This makes the point, that every company will have its own unique SIF precursor profile which reflects the risks present in particular area of operations (e.g. Smelting, Oil & Gas, and Construction). The author defines a routine precursor situation as *"a situation which is repeated on a regular basis during the course of normal operations."* A high proportion of precursor events were found by the author for the following routine situations:

- Driving
- Routine Maintenance
- Equipment Use
- Access/Egress

To begin to identify your own precursor situations it is worth being guided by the routine and non-routine categories highlighted here, and then let your own incident history database(s) inform you of your company's or facility's high-risk situations. From this, you can create a decision-tree such as that shown, that will help guide managers and supervisors to determine if an event had the potential to create an SIF.

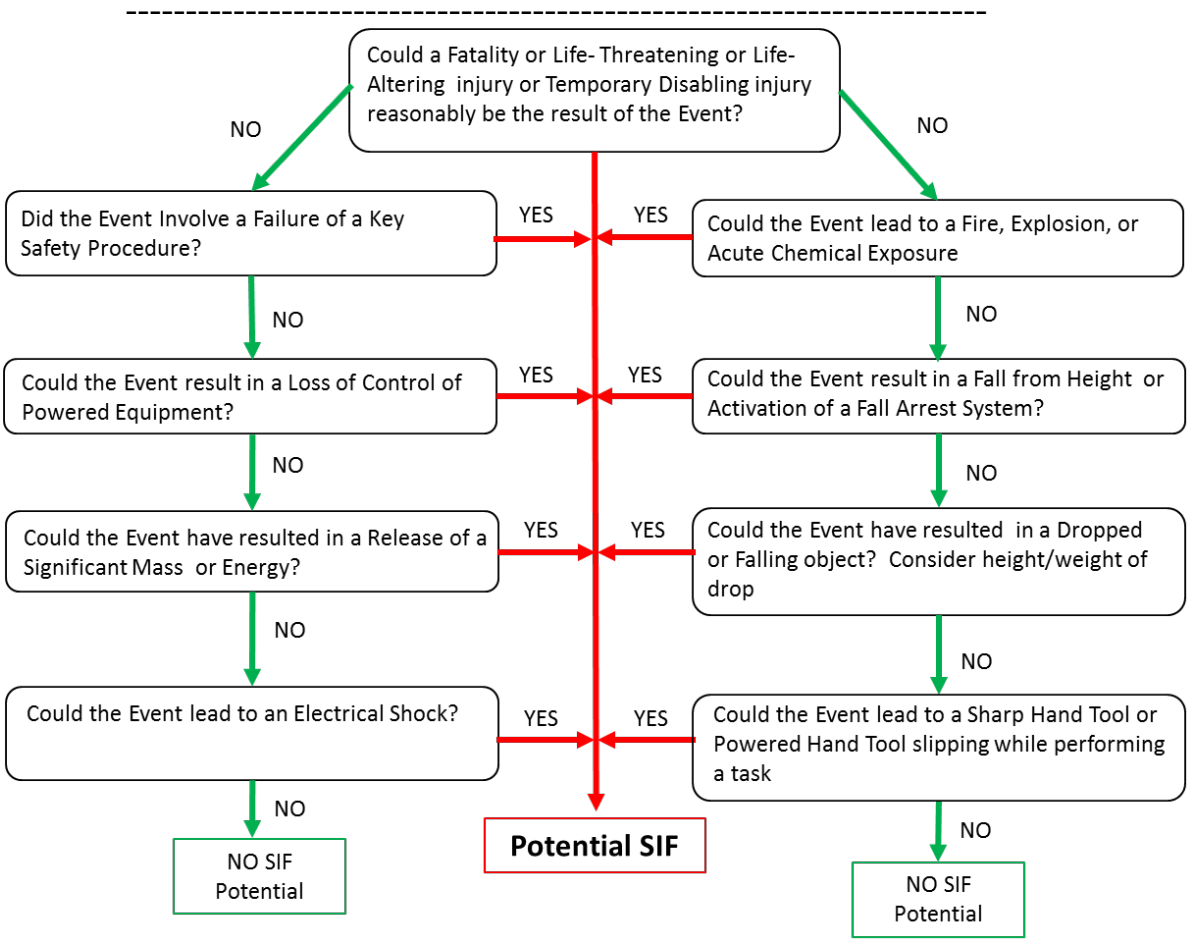

Figure 3: Potential SIF Decision-Tree

Identify and Define Exposure Activities

Within each Precursor Situation, it appears that potential SIF's are disproportionately related to activities 'managed' by certain safety controls (e.g. chemical handling, confined space entry, lifting operations, etc.). As such, an Exposure Activity is defined as "*work activities that would reasonably be expected to be controlled by a key procedure to prevent risk of injury*". Activities that have been identified as having a high proportion of potential SIF events include:

- Mobile equipment (operation and interaction with pedestrians)
- Confined space entry
- Jobs that require lock-out tag-out
- Lifting operations
- Working at height
- Manual handling
- Chemical handling
- Walking on same level
- Dropped object
- Use of tools

Identify and Define Underlying Cultural Contributors

Both Hale (2002) and Manuele (2008) linked Precursor Situations to an organisations safety culture, but this aspect has usually been overlooked by others reporting on their SIF programs. Offering the advantage of conducting a finer grained analysis and getting to the root causes, it makes sense to link any potential SIF analysis with 'Underlying Cultural Contributors' (e.g. communications).

In this way, it becomes possible to focus on a smaller number of opportunity areas to address a larger number of Precursor Situations and Exposure Activities (this is not to argue that these should be ignored). Typical 'Underlying Cultural Contributors' include people's individual behavioural choices, as well as those features under managements direct control such as leadership, job planning, job methods, sub-standard equipment, job pressures, and manning levels.

In the author's experience, people's behavioural choices account for around 56% of all potential SIF's, with poor management controls (e.g. job-planning, poor quality rules & procedures), and physical hazards and risks accounting for the remainder. Such results point to areas of opportunity for managerial safety leadership, and also provide opportunities that can cut down time, effort and costs associated with eliminating SIF's. For example, corrective actions focused on Job-planning could eliminate around 30% of potential SIF's and another 56% by focusing on people's behavioural choices.

The Way Forward

Potential SIF's are the outcome of organisational failings that should previously have been identified and addressed (Reason, 1998). There are usually many signals for impending incidents that typically take the form of 'close-calls', albeit, there is a reliance on people being able to recognise and report these.

Encouraging the reporting of close-calls and actual events presupposes [a] that there is a willingness to openly and proactively receive these reports, and [b] there is the means to easily capture and record such information (Roe et al., 2011). It has also been stated that 87% of all potential SIF's can be identified from safety observations (Krause, 2012) using BBS processes and safety leadership 'walk rounds'. Software to capture potential SIF's in real-time from BBS/Leadership conversations is now available (e.g. PEER®).

It is highly likely that incident databases will need to be adapted or developed to record and analyse the potential SIFs identified via 'close calls' and safety observation processes, to facilitate computation and tracking of a Potential SIF metric (i.e. Number of Potential SIF's / Man-hours Worked) that is regularly reviewed. At a minimum, reports should provide a clear description of the event and highlight [a] what happened; [b] any pre-existing risk controls at the time of the event; [c] actual hazards present at the time of the event; [d] actual consequences, [e] potential consequences; [f] the precursor situation; [g] the main exposure activity; [h] any underlying cultural

contributors, and if available [i] any root causes, in addition to normal information such as location, date, etc.

People will also need to be trained to identify potential SIF's, perhaps as part of a Hazard Identification process. This is one area where the definitions of Precursor Situations, Exposure Activities and Underlying Cultural Contributors are useful for developing focused potential SIF training programs so that people know exactly what to look for.

Conclusion

If the safety profession is to make significant progress in eliminating potential SIF Events, the profession must recognise that different strategies are required to control minor and severe injuries.

In practice, this likely means [a] improving incident data management; [b] integrating any SIF findings into existing safety systems; [c] providing SIF education to all concerned; [d] enhancing the quality of managerial safety leadership, who should test, question, and manage tasks with high-risk exposures; [e] developing and using a Potential SIF Rate that is widely shared with all; and [f] periodically reviewing the effectiveness of the overall SIF program. In this way, we could significantly reduce the nation's annual toll of deaths and serious injuries.

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Dr Dominic Cooper PhD, CFIOSH, C.Psychol. is chief executive of B-Safe Management Solutions (BSMS) Inc.