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PERSONNEL INJURIES/ILLNESSES ASSOCIATED
WITH NATURAL ENVIRONMENT HAZARDS

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ABSTRACT

The purpose of this paper is to demonstrate how an existing Department of Energy (DOE) resource can be used to gain valuable insight concerning injury/illness incidents. That resource is the Computerized Accident/Incident Reporting System (CAIRS) module of DOE's Safety Performance Measurement System (SPMS). Although this demonstration could have been performed by analyzing reports associated with any number of hazards (e.g., noise, chemicals, explosives, electricity, or tools-power/hand), the CAIRS data selected for analysis were the 1981-1991 DOE injury/illness reports that cited a "natural environment hazard" as either the direct or indirect cause of the injury/illness. Specifically, injury/illness reports were selected for analysis if they had a causal factor link to one or more of four natural environment hazard categories; weather, animal life, vegetation, or specific acts of nature (e.g., floods, earthquakes, and lightning strikes).

Approximately 3,100 CAIRS injury/illness reports were considered to have either a direct or an indirect causal link to at least one of the four natural environment hazard categories. These reports, which represent about eight percent of the total DOE injury/illness reports, documented nine deaths and more than 30,000 lost work days (the equivalence of nearly \$41,000,000).

The lessons learned, as a result of reviewing case histories, are presented, as are suggestions on how to reduce the likelihood of future injuries/illnesses as a result of similar hazards. A significant finding, is that most injuries/illnesses were the result of an indirect causal link to a natural environment hazard and thus, may be more preventable than previously thought possible. The primary message, however, is that CAIRS is a valuable resource and should be considered for use by those interested in identifying new ways of protecting the health and safety of the worker.

Introduction

The primary purpose of this paper is to demonstrate how an existing DOE resource, the Computerized Accident/Incident Reporting System (CAIRS), can be used to gain insight concerning how and why DOE personnel have been injured or become ill as a result of specific hazards. Though any of a number of hazards (e.g., excessive noise, radiation, scaffolding, confined spaces, or toxic materials) could have been selected for this demonstration, we chose to study those DOE injury/illness cases that were considered to be, either directly or indirectly, attributable to a broadened perspective of natural phenomena hazards (i.e., weather, animals, and vegetation, in addition to specific acts of nature).

The Department of Energy (DOE) has, and continues to, seek ways of reducing losses that can result from specific acts of nature. Several standards and guidelines have been developed, focussing on losses caused by earthquakes, tornadoes, floods, lightning, and volcanic ash. To date, losses from such acts have resulted primarily in property damage, rather than in personnel injuries or illnesses. While injuries or illnesses are certainly possible from these acts, they are much more likely to occur as a result of one of the less spectacular acts of nature, such as snow, ice, or wind storms, or simply the act of interfacing with the natural environment.

Methodology

Traditionally, natural phenomena hazards are thought of as catastrophic events, ranging from earthquakes and hurricanes to floods and lightning strikes. The scope of this study was expanded however, to include weather related events, as well as events involving personnel interactions with natural animal and plant life-forms.

The approximately 3,100 injury/illness cases reviewed for this study were selected from the set of over 40,000 injury/illness reports submitted by DOE and contractor organizations over the past ten years. These reports reside in the CAIRS module of the DOE's Safety Performance Measurement System (SPMS); the CAIRS' Search and Reports menu was the tool used to narrow the search for applicable cases and provide the lost workday (LWD) and dollar loss data.

The methodology used to select the 3,100 cases was to first search the CAIRS injury/illness data base for reports that contained certain Factor Relationship and Sequence of Events (FRASE) words or categories and then, based on the narrative content of these reports, perform a second (broader) search of the narratives of every injury/illness report for selected English vocabulary words associated with a specific hazard set. This second search was necessary to ensure the maximum percentage of applicable cases were identified, as some CAIRS reports are not yet FRASE coded and others may not be coded consistently. Typically,

reports obtained from this second (English vocabulary) search had to be reviewed to ensure that they were, in fact, applicable. An example of why this latter step is necessary was found in a report obtained from the search of the "ice" hazard set. In that report, a worker had fallen and injured his knee when he slipped on a wet spot that had developed due to personnel tracking "rain" water into his building. While this event was indirectly related to weather (rain), its only reference to "ice" was the "ice pack" that had been applied as a first aid measure. This report was subsequently excluded from the ice hazard set.

The most difficult aspect of the selection process was knowing when to exclude an event based on its causal factors being too "indirect" to the applicable hazard set. As mentioned earlier, injury/illness cases were only selected if they were either directly or indirectly associated (by way of causal factors) with one of the four categories of hazards; weather, animal life, plant life (vegetation), or a specific act of nature. The idea of direct association is not difficult; examples include: being struck by a large hail stone, being blown off one's feet, being bitten by a rattlesnake, contacting poison ivy, being swept away by a flash flood, and being struck by lightning. However, examples of indirect associations, which are analogous to contributing causes (as defined in DOE Order 5000.3A), are more difficult to define. Certainly slipping on an icy sidewalk, having a door blown shut on one's hand, falling down while running from a wasp, tripping over a vine, hurting one's back during sand bagging for a potential flood, or falling while

running to get out of a lightning storm are examples of indirect causal factors associated with natural environment hazards; but, at what point is a causal factor no longer really linked to a particular hazard?

The logic used during the selection process was to include only those cases where the corrective action(s) cited (or deemed to be required) were themselves linked to the applicable hazard. For example, if a car accident occurs because the car slid off a snow covered road, the corrective actions might be to counsel drivers to "avoid driving during snowy conditions unless absolutely necessary" or "drive more slowly during periods when the roads are slick." Similarly, if a car collides with a snowplow during a snow storm due to poor visibility, the corrective action may be a verbal warning or memo about the hazards of "blowing snow", especially in the vicinity of snowplows. Both examples would qualify as having indirect causal factors and would have been selected for this study. However, if the same car, on the same road, had collided with a snowplow on a calm, clear (non weather related) day, this case would have been excluded, even though some might argue that since a snowplow was involved, the case was weather related.

A special form of indirect causal factors was used for the "specific acts of nature" category. Indirect injuries/illnesses were categorized as being the result of either pre-event or post-event activities. Examples of pre-event activities are sandbagging, boarding up windows, and earthquake drills, while post-event activities involve interactions

(e.g., cleanup and/or rescue activities) with the many hazards that can result from specific acts of nature.

It should be noted that one pre-event activity, the installation of lightning arrester equipment, does not strictly meet our definition of an indirect causal factor, but is mentioned to make the point that there are always costs involved when taking steps to mitigate problems. This study identified ten reports in which individuals were injured (91 LWDs) by causal factors unrelated to lightning, or the environment, while installing lightning arrester equipment. While costly in terms of LWDs, these ten injuries were probably not too great a price to pay, given the potential dollar savings resulting from fewer equipment losses and outages. Such may not always be the case however; an injury vs. cost benefit analysis should always be performed prior to the start of any program designed to mitigate losses. The unforeseen side effects of some "cures" can sometimes be more costly than the consequences of the event being cured.

Findings

The 3,100 injury/illness cases considered to be linked to the natural environment represent approximately 8% of the total number of DOE injury/illness cases reported from 1981 to the present. These cases resulted in nine weather related deaths (primarily from vehicle accidents) and 30,578 LWDs. Though not reflective of the pain and

suffering endured by those involved and/or their loved ones, these deaths and LWDs cost the taxpayers nearly \$41,000,000. (The dollar cost figure is based on an equivalence formula developed for the DOE by the System Safety Development Center of EG&G Idaho, Inc.)

A breakdown of how the 3,100 cases are distributed by category, number, and number of LWDs is presented in Figure 1. Weather is seen to be, by far, the major natural environment hazard of the four considered, while injuries/illnesses as a result of specific acts of nature are two orders of magnitude less. Nearly all of the injuries/illnesses within each analyzed hazard set are considered to be the result of indirect (contributing) causal factors (i.e., those factors over which management has the most control, through the implementation of corrective actions).

While the primary purpose of the "direct-indirect" cause discussion has been to explain the logic used to select the events analyzed for this study, it is hoped that this discussion has also provided some insights to those individuals charged with the investigation of injury/illness events, such that they will be better equipped to identify applicable causal factors and recommend "event-based" corrective actions.

Weather Related Hazards

Weather related hazards accounted for over 82 percent of the cases, 92 percent of the LWDs, and all of the deaths identified in this study.

* Includes nine fatalities

Figure 1. Natural environment hazards

(Note: Eight of nine weather related deaths involved vehicle accidents). The predominate hazards are ice and snow, followed closely by wind. Slips, falls, and trips (1562) were the primary mechanisms that resulted in injury. When injury reports involving ice, snow, rain, wet, or mud were totaled (1578), this number correlated well with the set of slips, falls, and trips. Other mechanisms, involving snow and ice, that cause injuries involved: vehicle accidents, small mechanized and manual snow removal operations, attempting to lift or move frozen-in-place items, and lifting, in general, while standing on slick surfaces. One particularly unique mechanism involves large snow removal equipment. There have been numerous injuries as a result of snow removal equipment blades striking an immovable object such as manhole covers or railroad tracks, causing the equipment to come to an immediate stop.

Wind related injuries primarily result from: being struck by hinged windblown objects (e.g., doors); being struck, burned or contaminated by loose windblown objects (e.g., barrels, flames, hot asphalt, fumes); having small foreign objects blown into the eye(s); and being blown off one's feet or from an elevated location. In the latter example, it is extremely important to be aware of the presence of even mild winds, if personnel are carrying items that can, if turned, suddenly increase the surface area upon which the wind can act.

As with most natural environment hazards, which can combine their effects to form different hazards, wind in combination with extremely low temperatures can pose the danger of frost bite, while high

temperatures and winds can greatly increase the fire danger in certain areas. Temperature alone, in its extremes, can lead to hyperthermia or heat exhaustion. Combined with high humidity, heat exhaustion becomes even more likely. Anyone working outdoors, or even driving, needs to keep cognizant of the current and the predicted weather conditions. Driving on rain covered highways can suddenly become deadly if the surface temperature unexpectedly drops below 32°F.

Visibility, another weather related hazard, is highly affected by factors such as wind, snow, rain, humidity, and temperature. Fog, dust, smoke, and frosted windows can make driving a hazardous experience. Even if not driving, a person's eye glasses can become fogged, thus possibly precipitating an injurious trip or fall.

Backs were the body part most often injured as a result of weather related hazards (387 cases and 5506 LWDs). Other body parts suffering a high number of injuries include: knees (230 and 3333), ankles (182 and 2447), and necks/shoulders (163 and 3124). Though no correlation was performed with the type of injury, it is not difficult to speculate that strains and sprains accounted for many of the injuries.

Eyes were affected in a large number of cases (365) but resulted in few LWDs (216). The potential is none-the-less present for a high consequence injury in this area and ways of reducing the number of eye injuries should be vigorously sought.

Animal Life-Form Hazards

The search for injuries from animal life-forms was limited to non-domestic animals in their natural environment. Injuries involving caged laboratory animals or domestic animals in the environment were excluded, with one exception, injuries resulting from the training of guard dogs are mentioned, given the number (10) of reported cases.

Injuries caused by lower-order life-forms resulted primarily from personnel being bitten or stung by any of a large variety of insects. While these injuries are usually not life threatening, some individuals do have strong allergic reactions to the bite or sting of certain insects. Supervisors should be cognizant of who these individuals are, before sending personnel into an area where such hazards may be prevalent. Another growing concern involving insects is Lyme's disease. This study identified 16 tick bite cases, in which six individuals were confirmed to have contracted Lyme's. Fire ants can also be a big surprise to those individuals who are unfamiliar with this southern state hazard.

In addition to bites and stings, there are other mechanisms by which personnel can be injured as a result of insects. For example, flying insects can strike the eyes of those walking, driving with their window down, or riding a bicycle (as is often done at some DOE sites for local

transportation). Personnel have also become ill as a result of inadvertently inhaling airborne insecticides. The most notable mechanism however, is one termed "avoidance." In terms of severity, injuries resulting from avoidance activities are usually much worse than those that would have resulted from the bite or sting itself. There are cases where personnel have had car accidents, slammed doors on their hands, and even jumped from high places, while trying to escape from an insect. Others have cut themselves or coworkers with items they had in their hands while swatting at insects. One individual even cut his arm on a window he broke while swiping at an insect. Personnel with avoidance tendencies should be identified and advised as to the potential consequences of their actions. They may decide a bite or sting is preferable to stitches, casts, or worse.

The predominance of personnel interactions with higher-order animals are vehicle related. Deer, wild horses, wild hogs, and even rabbits and squirrels, have been the indirect cause of vehicle accidents involving DOE personnel. With the exception of wild horses, which are limited to parts of New Mexico, and wild hogs (in some southern states), the other animals involved are found in every state and personnel must be periodically reminded of the hazard they represent. Most of the injuries sustained during these vehicle accidents were the result of over-zealous avoidance attempts; squirrels, rabbits, and even deer, seldom pose a missile threat to the occupants of a vehicle during a collision.

The higher life-form hazard set also contains a number of injuries resulting from non-vehicle avoidance activities, where the costs (in terms of LWDs) were greater than would have probably occurred had the individuals actually come in contact with the animal. Consequences of these ill-fated avoidance attempts include: a backward fall down a stairs after seeing a skunk, a cut hand while trying to scare away raccoons, a fall while running from startled raccoons, and a severe laceration after being startled by a snake (69 LWDs).

Avoidance activities, while more justified for higher life-forms, should, to the extent possible, be performed calmly. One method of gaining the skills necessary to accomplish this is for the individual to occasionally visualize the most probable hazard, in relation to his/her immediate surrounding, and ask "What should I do if the hazard suddenly appears?"

Snake bites are a real danger to those who must work outdoors in certain parts of the country. However, their number and consequence could be lessened if personnel were provided better training in avoidance techniques and first aid, and protective clothing and equipment.

The relative high number of injuries (10) involving guard dog training prompts mention, even though these dogs are domestic animals. Security personnel involved in the training of these animals should be reminded of the dogs' unpredictability and wear protective clothing and equipment

during all training activities. Fractures and a herniated disk are just some of the injuries suffered during guard dog training activities.

Vegetation Hazards

There were 210 injury/illness cases (with 1,230 LWDs) considered to be applicable to the hazards involved with plant life in the natural environment. The most probable way personnel can be injured or made ill by interfacing with plant life involves poisonous plants such as poison ivy, oak, and sumac. There were 112 reports of personnel coming in contact with, and developing a reaction to, the toxins of such plants. Poison ivy is the most prevalent hazard; it was named in 82 reports. The consequence of contacting poisonous plants are not great however; only 140 LWDs resulted from the 112 cases.

In terms of consequences, activities involving the clearing of vegetation such as trees, brush, and weeds have proven to be much more hazardous. Even the simple act of mowing lawns has caused a high number of LWDs. One lawn mower accident alone, accounted for over 200 LWDs. All totalled, 71 injury cases involved the clearing of vegetation.

Trips and falls were cited in 57 of the vegetation related injury reports. Vegetation in some forms are easy to trip on, while other forms tend to conceal depressions, holes, rocks or other hazards.

Specific Acts of Nature

Only three direct injuries were identified as being the result of a specific act of nature. Two injuries resulted from lightning strikes, and the third resulted from an avoidance activity during an earthquake (the latter individual strained his back while diving under a desk).

The remaining 37 "act of nature" cases were the result of either pre-event (29) or post-event (8) activities. (Note: These 37 cases were categorized as pre-event or post-event, rather than as indirect, because, unlike the other hazards discussed, specific acts of nature are only present for a finite period of time.)

Pre-event activities include: preparedness drills for hurricanes, tornadoes, and earthquakes; sand bagging in preparation for floods; and the installation of lightning protection equipment (even though this latter activity was primarily performed to protect property, as opposed to lives).

Post-event activities are typically those cleanup or rescue activities that may be required after certain events. Both pre-event and post-event activities are similar to avoidance activities in that they are often stressful and performed with a sense of urgency, especially if the act of nature is imminent or has just recently occurred. Cleanup and rescue activities can be particularly hazardous, given the immediate

presence of a new set of unknown hazards. Supervisors should caution those personnel involved in such activities to keep calm and keep their mind on their task and the dangers at hand.

Conclusions

In addition to demonstrating the usefulness of CAIRS data, it is hoped that the results of this study have broadened the reader's perception of natural environment hazards (as well as hazards in general). While much has been done in an attempt to mitigate the consequences of specific acts of nature, the investigation of weather, and other environment related events, are often performed in perfunctory manner or even dismissed as being beyond prevention; after all, "it always snows in the winter" (in most locales) and "deer are always running in front of cars" and "the grass and weeds always have to be cut in summer." What shouldn't "always" have to happen however, is for personnel to continue, year after year, to be injured (or killed) as a result of simply interfacing with the natural environment, without some effort being made to change the process.

If all injuries identified by this study had been the result of direct causal factors, little could have been done, in terms of corrective actions, except to propose that personnel be kept from interfacing with such hazards (time - space separation), a highly impractical solution. However, the predominance of these injuries were due to indirect causal

factors. Therefore, recurrence of a large number of similar events could have been prevented had the original investigative and closeout processes resulted in: 1) the identification of all applicable causal factors and 2) the implementation of an effective corrective action for each identified factor.

Generic corrective actions that, if implemented, would have helped prevent recurrence of many of the kinds of injuries identified in this study include: the selection of "proper" personnel for the task (where proper relates to qualifications, level of training, physical attributes, or known stress limits), the redesign of equipment, the issuance or revision of operating procedures, and the required use of adequate protective equipment and clothing. In many cases, little more than making cognizant personnel aware of specific hazards would reduce the number of future injuries from such hazards. Hazard awareness can be accomplished by the implementation of a simple "lesson learned" program. Such a program can be managed by one or two individuals, who are charged with analyzing CAIRS or other occurrence reports and periodically disseminating their findings to applicable personnel at their site by way of a "required-reading" program.

By now, it should be apparent that the real message of this paper goes beyond demonstrating how CAIRS can be used to identify (and hopefully correct) the causes of recurring injuries/illnesses. The message that we want to present is that any event, whether it involves injury or

property damage, whether it is caused by a horse fly, a saw horse, or horse play, must be investigated in sufficient depth at the time of the event (not later, after it happens again) to ensure: 1) the identification of the event's true root cause and all contributing causes (factors), and 2) the formulation and implementation of corrective actions that are directed toward more than just the person or persons involved in the event. It is too easy to blame the weather or the injured individual, rather than asking the hard questions whose answers might require the expenditure of resources; but only by doing so, will we start to see a reduction in the number, and the severity, of those events that are presently being experienced at DOE sites.

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