LOSS CAUSATION AND INCIDENT INVESTIGATION

ELEMENT 2

LEARNING OUTCOMES

On completion of this element, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations and the critical analysis and evaluation of information presented in both quantitative and qualitative forms. In particular you should be able to:

1. Explain theories of loss causation.
2. Explain the quantitative analysis of accident/incident and ill-health data, limitations of their application, and their presentation in numerical and graphical form.
3. Explain the external and the internal reporting and recording systems for loss events (injuries, ill health, dangerous occurrences) and near misses.
4. Explain loss and near-miss investigations; the requirements, benefits, the procedures, the documentation, and the involvement of and communication with relevant staff and representatives.

Contents

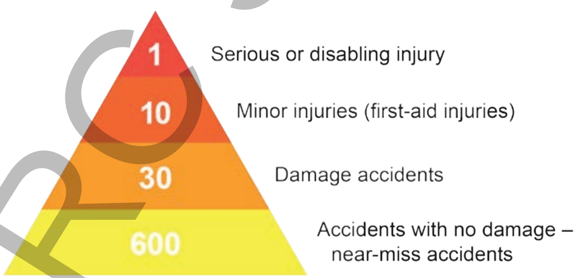
KEY INFORMATION

- Incident studies have demonstrated that in any organisation there is a relationship between the number of major incidents and those with less serious outcomes.
- The Single Cause Domino Theory suggests that in an accident there is a sequence of events or circumstances that precede the harm, i.e.
  - Ancestry (i.e. upbringing).
  - Fault.
  - Unsafe act.
  - Accident.
  - Injury.
- Multi-causal theories suggest that preceding an incident there is a combination of causal factors at each level that may combine to lead to the loss event.
- Reason's model of organisational accidents states that for a major accident to occur a series of defences must be defeated for the hazard to lead to a loss event. Unsafe acts may cause the failure of the defences. Unsafe acts are made more likely by local conditions in the workplace.

ACCIDENT/INCIDENT RATIO STUDIES

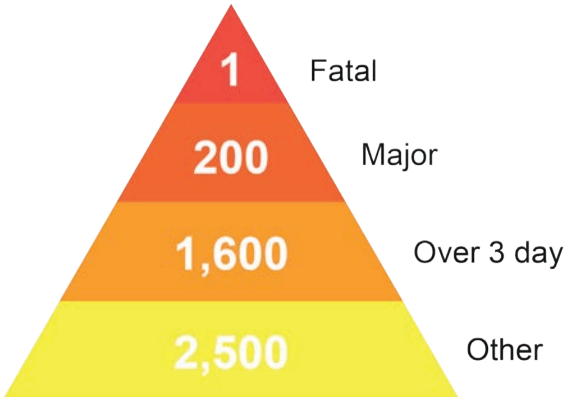
There is no shortage of data on incidents such as accidents or near misses. Some researchers have studied the figures in detail and concluded that there appears to be a relationship between the numbers of different types of accident.

F. E. Bird used accident data to produce the following **accident triangle**:



Bird's accident ratio triangle

Other researchers have produced similar accident ratio triangles:



Labour force survey 1990

UK accident data

Heinrich's accident triangle

The actual figures vary between the different accident triangles, but the important thing to note is that for every major incident or fatality, there are many more less serious or near-miss incidents.

Analysis also shows that:

- It is invariably a matter of chance whether a given event results in injury, damage, or a near miss, i.e. near misses could so easily become more serious incidents.
- Near-miss/less-serious incident data can, therefore, be a useful predictor of accident potential.
- All events are due to failure to control – so we can learn from even minor incidents.

The data from these triangles has a number of limitations that you need to think about before trying to apply it:

- Not every near miss or minor incident involves risks which could actually have led to a serious incident or fatality.
- Be careful comparing:
  - Different triangles.
  - Different definitions (e.g. lost-time accidents).
  - Different industries (with different types of risk).
- Statistical significance – you need a certain amount of representative data for a meaningful comparison between your workplace and industry as a whole.

DOMINO AND MULTI-CAUSALITY THEORIES

One of the duties of the safety practitioner is to keep details of accidents and ill-health conditions and carry out investigations. The law requires certain accidents and occupational diseases to be reported. Often the information that is recorded at the time of an accident is not adequate for the purpose of investigation into the cause, and so is certainly inadequate for the purpose of preventing the accident happening again.

For example, the report form may ask for the nature and cause of the injury. This could be written as:

- Nature of injury - cut finger.
- Cause of injury - caught on a sharp piece of metal.

The safety practitioner needs to know a lot more than this such as:

- Which finger?
- How serious was the cut?
- Was this part of the normal job?
- Should it have been sharp?
- Should it have been there?
- How should it have been handled?

A good starting point in investigations is to consider the two basic theories for accident causation.

Note that domino theory presents a simplified model, which considers only one cause of an accident. Also, in the Heinrich model, the focus is on immediate rather than root causes. Both models are highly reactive and cannot be used to predict the likelihood of accidents.

Single Cause Domino Theory

According to **Heinrich**:

> *"A preventable accident is one of five factors in a sequence that results in an injury. The injury is invariably caused by an accident and the accident in turn is always the result of the factor that immediately precedes it."*

The five factors in Heinrich's accident sequence are summarised in the following table.

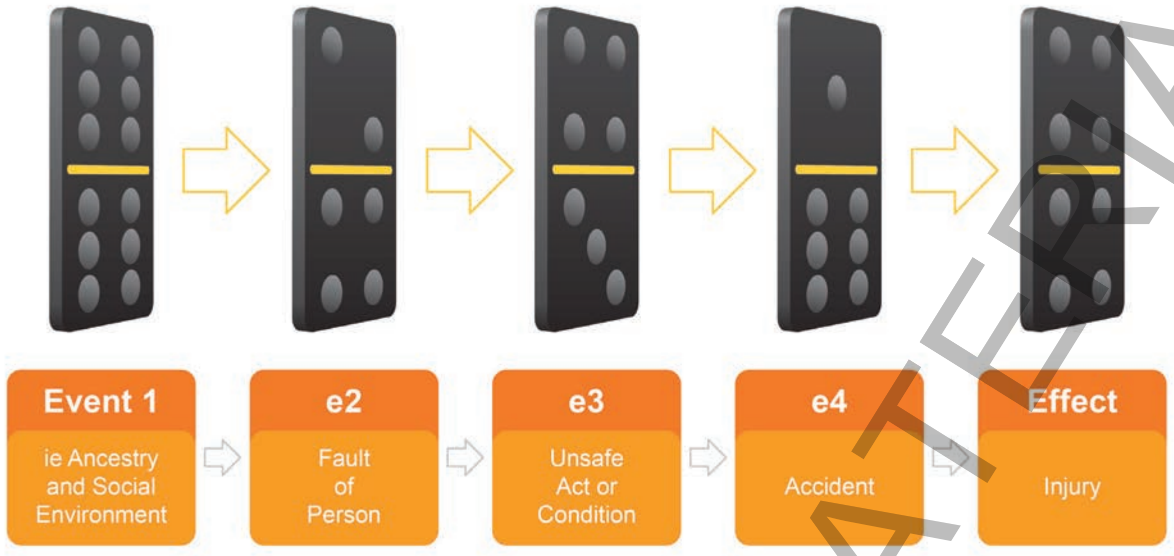
Heinrich's accident sequence

Accident Factors	Description
1. Ancestry and social environment	Recklessness, stubbornness, greed and other undesirable traits of character that may be passed along through inheritance. Environment may develop undesirable traits of character or may interfere with education. Both inheritance and environment may cause faults of person.
2. Fault of person	Inherited or acquired faults of person such as recklessness, violent temper, nervousness, excitability. These constitute reasons for committing unsafe acts or for the existence of mechanical or physical hazards.
3. Unsafe act and/or mechanical or physical hazard	Unsafe performance of persons such as: standing under danger areas, careless starting of machines, removal of safeguards and horseplay; mechanical or physical hazards such as unguarded gears or points of operation, insufficient light, which result in accidents.
4. Accident	Events such as falls of persons, striking of persons by flying objects, etc. are typical accidents which cause injury.
5. Injury	Fractures, lacerations, etc. are injuries which result directly from accidents.

The major point that Heinrich makes is that a preventable injury is the natural culmination of a series of events or circumstances which occur in a fixed logical order. Here an analogy can be made with a row of dominoes placed on end, such that if one falls it will cause the next to fall and so on throughout the series (see figure that follows). If one of the dominoes is removed, the chain of events will be halted. In the same way, consider Heinrich's accident sequence:

1. Ancestry and social environment.
2. Fault of person.
3. Unsafe act and/or mechanical or physical hazard.
4. Accident.
5. Injury.

If this sequence is interrupted by the elimination of even one of these factors, the injury cannot occur and the accident has been prevented. In the case of the accident sequence, perhaps the easiest factor to eliminate is Number 3, the "unsafe act and/or mechanical or physical hazard".



Heinrich's domino sequence

Bird and Loftus extended Heinrich's theory to take into account the influence of management in the cause and effect of accidents, suggesting a modified sequence of events:

1. Lack of control by management.
2. This permits the existence of basic causes (i.e. personal and job factors).
3. In turn, this leads to immediate causes (such as sub-standard practices, conditions or errors).
4. These are subsequently the direct causes of the accident.
5. Finally, this results in loss (which may be categorised as negligible, minor, serious, or catastrophic).

This modified sequence can be applied to every accident and is of basic importance to loss-control management.

Multi-Causal Theories

There may be more than one cause of an accident, not only in sequence, but occurring at the same time. For example, a methane explosion requires:

- Methane in the explosive range of 5% to 15%.
- Oxygen, or air.
- Ignition source.

The ignition will only happen if these three events occur together. Each of the three events may, in themselves, be the end result of a number of different sequences of events. In accident investigation, all causes must be identified.

Usually simple accidents have a single cause, which is why such events so frequently occur; but the consequences tend to be of a minor nature. A major disaster normally has multiple causes, with chains of events, and combinations of events. Fortunately, they are rare occurrences.

The multi-causal model considers that there may be organisational, cultural, managerial, etc. causes that interact and result in an accident. The model is more complex than the single-cause domino theory and can be used not only for accident investigation, but also to prevent accidents if the outcomes of monitoring activities are analysed. The model can also be linked to more advanced analysis techniques, such as fault trees and event trees. The downside is that they are more complex and therefore take longer to carry out.

Systems Theory

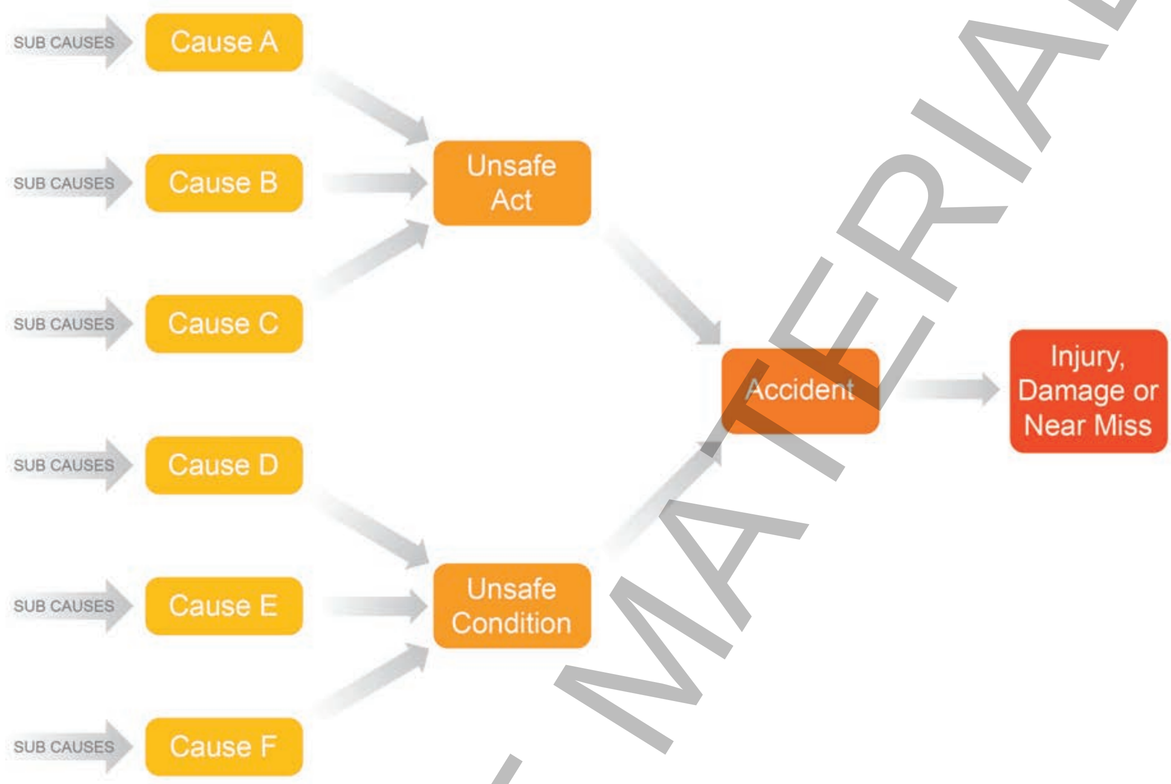
This is another way of looking at a multiple cause situation.

Factories and processes can be viewed as systems, i.e. an assembly of parts or components connected together in an organised way to perform a task, with inputs and outputs, and various kinds of control mechanisms.

A systems approach is often useful in simplifying complex operations. Part of the system can be taken as a 'black box', with only the inputs and outputs considered.

System failures are prevented or minimised by components which cannot fail, by backup systems, or by redundancy built into the system (see Element IA4). Accidents happen in our system because it includes fallible components such as machines and human beings. The system is operating in the failure mode.

You can see the essential features of the multiple causation approach in the following figure.



Features of the multiple causation approach

IMMEDIATE, UNDERLYING AND ROOT CAUSES

There are various ways of classifying accident causes. Remember that the same term may be used by different people to mean different things – you can check this for yourself by doing an Internet search on the above terms.

When analysing accidents it is common to distinguish between immediate causes and underlying causes. The latter are also sometimes called root causes. The term used can vary, but the most important thing to remember is to look beyond the symptoms of the accident. You need to dig down beyond the obvious (immediate) causes to discover why it happened, or why it was allowed to happen. Usually, an accident occurs as a result of multiple chains of events; following these back will lead to underlying causes, tackling which can stop similar accidents happening again.

- **Immediate cause** refers to the direct cause of the accident, i.e. the actual agent of injury or damage, such as the sharp blade of the machine.
- **Underlying, or root causes** are the less obvious systemic, or organisational reasons for the incident.

We will now look at unsafe acts and conditions in more detail.

An **unsafe act** is human performance that is contrary to accepted safe practice and which may, of course, lead to an accident. **Unsafe conditions** are basically everything else that is unsafe after you take away unsafe acts. So, this is the physical condition of the workplace, work equipment, the working environment, etc. which might be considered unsafe and could therefore foreseeably lead to an accident if not dealt with.

Note that an unsafe act or unsafe condition alone could result in an accident. For example, "messing around" is an unsafe act which could take place in otherwise safe conditions, but could nevertheless result in an accident. Similarly, a person could be working in a perfectly safe manner, using safe equipment and materials, but suffer injuries as the result of the collapse of a floor affected by severe woodworm and dry rot. (You could argue, however, that collapse of the floor was due to an unsafe act, i.e. failure to inspect the floor and supporting joists and to calculate the floor loadings.)

According to the accident sequence we discussed earlier, unsafe acts and conditions are caused only by faults of persons, and these faults are created by the environment, or are acquired by inheritance.

The faults themselves generally arise because of inappropriate attitudes, lack of knowledge or skill, or physical unsuitability.

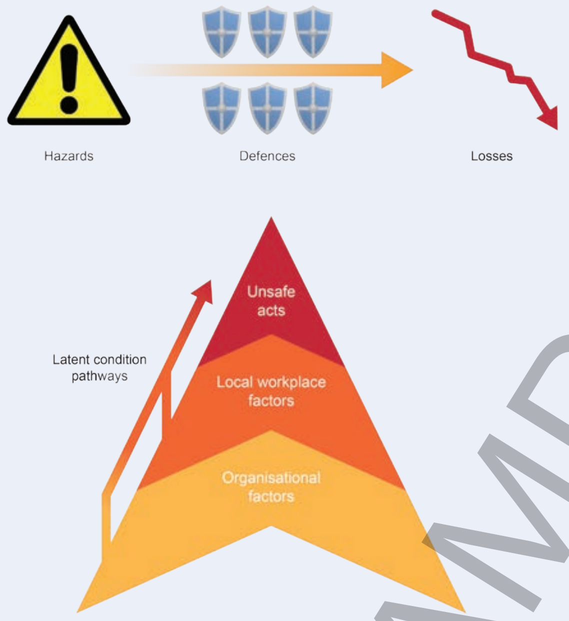
REASON'S MODEL OF ACCIDENT CAUSATION

TOPIC FOCUS

Latent and Active Failures

Rather than using the words "immediate", "underlying" or "root" causes, the terms "latent" and "active" failures are also commonly used.

Following research into a series of disasters, **James Reason** (an occupational psychologist) has developed a model of accident causation for organisational accidents. An organisational accident is rare, but if it happens it often has disastrous consequences (e.g. Piper Alpha, North Sea, 1988). Reason's model shows that organisational accidents do not arise from a single cause but from a combination of active and latent failures.



Adapted Version of Reason's Model of Accident Causation

In the model there is a series of defence barriers between the hazard and a major incident. These not only prevent the incident, (e.g. containment of the hazard, safe operating procedures, etc.) but also provide warning of danger (e.g. an alarm) and mitigate the consequences (e.g. means of escape). These multiple layers characterise complex technological systems such as a chemical plant.

(Continued)

TOPIC FOCUS

However the barriers are not perfect and can be defeated.

Active failures are one cause for the barriers to be defeated.

Active failures are those unsafe acts which have immediate effects on the integrity of the system and are usually committed by those directly involved in the task. Such individuals often suffer directly as a result of the incident and may often be blamed as well. The cause of the failure will be due to an error (accidental) or a violation (deliberate). Such unsafe acts occur regularly, but few will cause the defences to be penetrated, an example being the chemical plant operator who opens a valve allowing a hazardous substance to escape.

The model then shows that the local workplace factors influence the chance of an unsafe act occurring. In the case of the hazardous substance escape, this may be due to a lack of supervision or training, maintenance failure, unworkable procedures, etc.

According to the model the local workplace factors are affected by decisions made at a strategic level by senior management, government, regulators, manufacturers, etc. In the case of senior management this might be lack of recognition of the importance of occupational health and safety, which will be reflected in the culture of the organisation by the behaviour that is considered acceptable. The management may give safety a low priority with no commitment and minimal funding. These failures at the strategic levels, both in the organisation and the external environment, are described as **latent failures** because they remain dormant and possibly unrecognised until they interact with the local factors and the unsafe acts and work environments, and increase the likelihood of an active failure.

When the gaps created by active failures align with those created by the latent conditions, the opportunity exists for a serious outcome.

Categories of Unsafe Acts

Unsafe acts of persons may be categorised under the following headings:

- Operating without authority.
- Operating or working at an unsafe speed.
- Making safety devices inoperative.
- Using unsafe equipment, or using equipment unsafely.
- Unsafe methods, e.g. loading, carrying, mixing.
- Adopting an unsafe position or posture.
- Working on moving or dangerous equipment.
- "Messing/playing around", e.g. distracting, teasing, startling.
- Failure to wear safe clothing or personal protective devices.
- Lack of concentration; fatigue or ill health.

From this list you can see that unsafe acts may either be deliberate violations (sometimes called 'active') or unintentional errors (sometimes called 'passive'). We discuss these 'human factors' in detail in Element IA7.

Categories of Unsafe Conditions

The following categories describe unsafe conditions from which an accident may result:

- Inadequate guarding; guards of inadequate height, strength, mesh, etc.
- Unguarded machinery, or the absence of the required guards.
- Defective, rough, sharp, slippery, decayed, cracked surfaces.
- Machines/tools designed with insufficient attention to safety.
- Unsafe arrangements, poor housekeeping, congestion, blocked exits.
- Inadequate lighting, glare, reflection.
- Inadequate ventilation, contaminated air.
- Unsafe clothing - no goggles, gloves or mask.
- Unsafe processes - mechanical, chemical, electrical, nuclear.
- Hot, humid or noisy environment.

REVISION QUESTIONS

1. Outline the five factors in Heinrich's accident sequence.
2. How does Bird and Loftus' theory of accident causation differ from Heinrich's?
3. According to Reason, what in an organisation are "latent failures"?
4. What important principle of accident causation theory do accident ratio studies illustrate?

(Suggested Answers are at the end.)