

# Reviewing Heinrich

## Dislodging Two Myths From the Practice of Safety

By Fred A. Manuele

In *The Standardization of Error*, Stefansson (1928) makes the case that people are willing to accept as fact what is written or spoken without adequate supporting evidence. When studies show that a supposed fact is not true, dislodging it is difficult because that belief has become deeply embedded in the minds of people and, thereby, standardized.

Stefansson pleads for a mind-set that accepts as knowledge only that which can be proven and which cannot be logically contradicted. He states that his theme applies to all fields of endeavor except for mathematics. Safety is a professional specialty in which myths have become standardized and deeply embedded. This article examines two myths that should be dislodged from the practice of safety:

1) Unsafe acts of workers are the principle causes of occupational accidents.

2) Reducing accident frequency will equivalently reduce severe injuries.

These myths arise from the work of H.W. Heinrich (1931; 1941; 1950; 1959).

They can be found in the four editions of *Industrial Accident Prevention: A Scientific Approach*. Although some safety practitioners may not recognize Heinrich's name, his misleading premises are perpetuated as they are frequently cited in speeches and papers.

Analytical evidence indicates that these premises are not soundly based, supportable or valid, and, therefore, must be dislodged. Although this article questions the validity of the work of an author whose writings have been the foundation of safety-related teaching and practice for many decades, it is appropriate to recognize the positive effects of his work as well.

This article was written as a result of encouragement from several colleagues who encountered situations in which these premises were cited as fact, with the resulting recommended preventive actions being inappropriate and ineffective. Safety professionals must do more to inform about and refute these myths so that they may be dislodged.

### Recognition: Heinrich's Achievements

Heinrich was a pioneer in the field of accident prevention and must be given his due. Publication of his book's four editions spanned nearly 30 years. From the 1930s to today, Heinrich likely has had more influence than any other individual on the work of occupational safety practitioners. In retrospect, knowing the good done by him in promoting greater attention to occupational safety and health should be balanced with an awareness of the misdirection that has resulted from applying some of his premises.

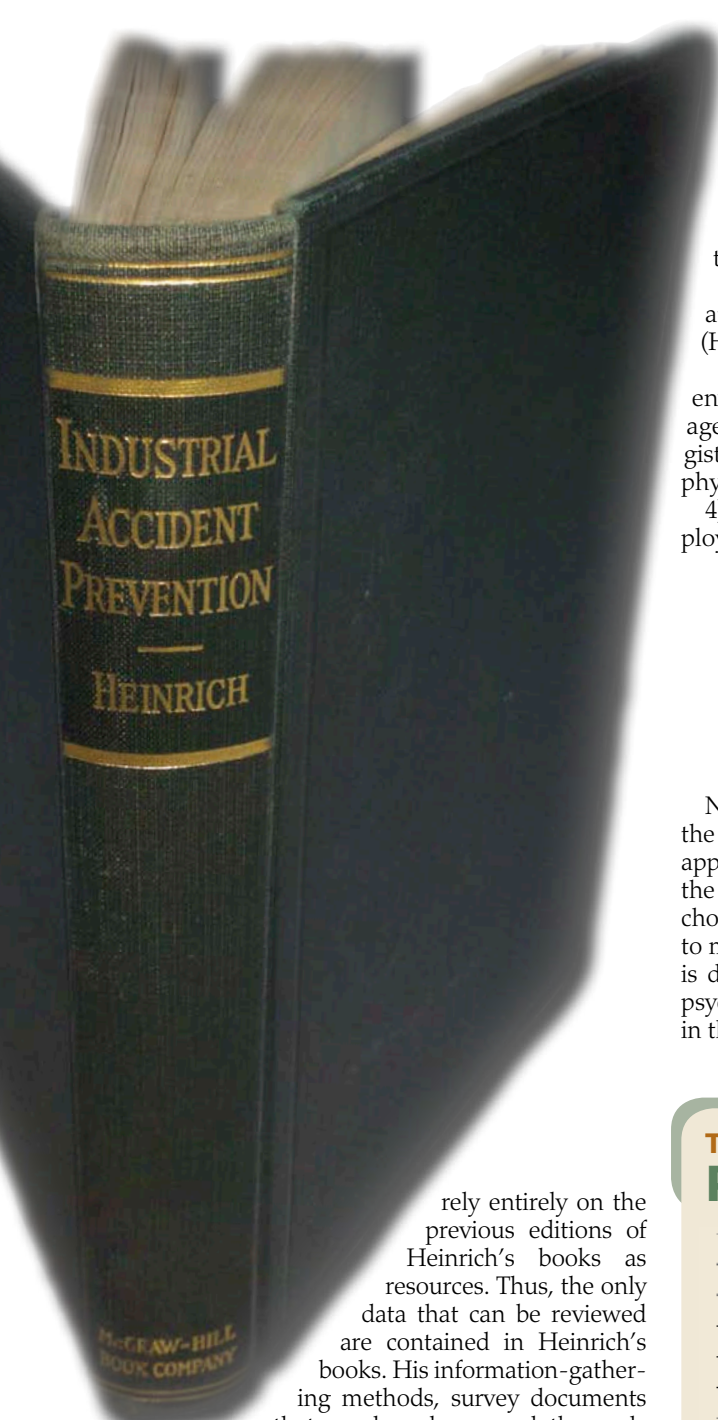
### Heinrich's Sources Unavailable

Attempts were made to locate Heinrich's research, without success. Dan Petersen, who with Nestor Roos, authored a fifth edition of *Industrial Accident Prevention*, was asked whether they had located Heinrich's research. Petersen said that they had to

### IN BRIEF

- This article identifies two myths derived from the work of H.W. Heinrich that should be dislodged from the practice of safety: 1) unsafe acts of workers are the principal causes of occupational accidents; and 2) reducing accident frequency will equivalently reduce severe injuries.
- As knowledge has evolved about how accidents occur and their causal factors, the emphasis is now correctly placed on improving the work system, rather than on worker behavior. Heinrich's premises are not compatible with current thinking.
- A call is issued to safety professionals to stop using and promoting these premises; to dispel these premises in presentations, writings and discussions; and to apply current methods that look beyond Heinrich's myths to determine true causal factors of incidents.

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- 1) Heinrich expresses the belief that “psychology in accident prevention is a fundamental of great importance” (H-1).
- 2) His premise is that “psychology lies at the root of sequence of accident causes” (H-2).
- 3) In the fourth edition, Heinrich states that he envisions “the more general acceptance by management of the idea that an industrial psychologist be included as a member of the plant staff as a physician is already so included” (H-3).
- 4) The focus of applied psychology on the employee, as in the following quotation:

Indeed, safety psychology is as fairly applicable to the employer as to the employee. The initiative and the chief burden of activity in accident prevention rest upon the employer; however the practical field of effort for prevention through psychology is confined to the employee, but through management and supervision. (H-4)

Note that the focus of applied psychology is on the worker as are other Heinrichean premises. Since application of practical psychology is confined to the worker, who reports to a supervisor, the psychology applier is the supervisor. With due respect to managers, supervisors and safety practitioners, it is doubtful that many could knowledgeably apply psychology “as a fundamental of great importance” in their accident prevention efforts.

rely entirely on the previous editions of Heinrich’s books as resources. Thus, the only data that can be reviewed are contained in Heinrich’s books. His information-gathering methods, survey documents that may have been used, the quality of the information gathered and the analytical systems used cannot be examined.

Two items of note for this article: Citations from Heinrich’s texts are numbered H-1, H-2, etc., and correspond to the chart in Table 1, which indicates the page numbers and editions in which each citation appears. All other citations appear as in-text references in the journal’s standard style.

Furthermore, in today’s social climate, some of Heinrich’s terminology would be considered sexist. He uses phrases such as *man failure*, *the foreman* and *he is responsible*. Consider the time in which he wrote. The fourth edition was published in 1959.

### Psychology & Safety

Applied psychology dominates Heinrich’s work with respect to selecting causal factors and is given great importance in safety-related problem resolution. Consider the following:

**Table 1**  
**Pages Cited by Edition**

Citation	1st 1931	2nd 1941	3rd 1950	4th 1959
H-1	128	269	32	17
H-2	127	268	325	173
H-3				171
H-4	127	268	325	173
H-5	45	19	18	21
H-6	128	269	326	174
H-7		22	2	4
H-8		20	18	21
H-9	44	20	18	20
H-10	95	34	31	33
H-11	31			
H-12		26		
H-13	91			
H-14		27	24	27
H-15		27	24	27
H-16				31
H-17		26		
H-18			24	26
H-19			24	26
H-20	101			
H-21			188	
H-22	22			28



Analytical evidence indicates that several of Heinrich's premises, first introduced in 1931, are not soundly based, supportable or valid, and, therefore, must be dislodged.

### Heinrich's Causation Theory: The 88-10-2 Ratio

Heinrich professes that among the direct and proximate causes of industrial accidents:

- 88% are unsafe acts of persons;
- 10% are unsafe mechanical or physical conditions;
- 2% are unpreventable (H-5).

According to Heinrich, man failure is the problem and psychology is an important element in correcting it. In his discussion of the relation of psychology to accident prevention, Heinrich advocates identifying the first proximate and most easily prevented cause in the selection of remedies. He says:

Selection of remedies is based on practical cause-analysis that stops at the selection of the first proximate and most easily prevented cause (such procedure is advocated in this book) and considers psychology when results are not produced by simpler analysis. (H-6)

Note that the first proximate and most easily prevented cause is to be selected (88% of the time a human error). That concept permeates Heinrich's work. It does not encompass what has been learned subsequently about the complexity of accident causation or that other causal factors may be more significant than the first proximate cause.

For example, the *Columbia* Accident Investigation Board (NASA, 2003) notes the need to consider the complexity of incident causation:

Many accident investigations do not go far enough. They identify the technical cause of the accident, and then connect it to a variant of "operator error." But this is seldom the entire issue. When the determinations of the causal chain are limited to the technical flaw and individual failure, typically the actions taken to prevent a similar event in the future are also limited: fix the technical problem and replace or retrain the individual responsible.

Putting these corrections in place leads to another mistake: The belief that the problem is solved. Too often, accident investigations blame a failure only on the last step in a complex process, when a more comprehensive understanding of that process could reveal that earlier steps might be equally or even more culpable.

A recent example of the complexity of accident causation appears in this excerpt from the report prepared by BP personnel following the April 20, 2010, *Deepwater Horizon* explosion in the Gulf of Mexico (BP, 2010):

The team did not identify any single action or inaction that caused this incident. Rather, a complex and interlinked series of mechanical failures, human judgments, engineering design, operational implementation and team interfaces came together to allow the initiation and escalation of the accident.

Consider another real-world situation in which a fatality resulted from multiple causal factors:

An operation produces an odorless, colorless highly toxic gas in an enclosed area. The two-level gas detection and alarm system has deteriorated over many years of use, and the system often leaks gas. An internal auditor recommends it be replaced with a three-level system, the accepted practice in the industry for that type of gas. The auditor also recommends that maintenance give the existing system high priority.

Management puts high profits above safety and tolerates excessive risk taking. That defines culture problems. Management decides not to replace the system, and furthermore begins a cost-cutting initiative that reduces maintenance staff by one-third. The gas detection and alarm system continue to deteriorate, and maintenance staff cannot keep up with the frequent calls for repair and adjustment.

A procedure is installed that requires employees to test for gas before entering the enclosed area. But, supervisors condone employees entering the area without making the required test. Both detection and alarm systems fail. Gas accumulates. An employee enters the area without testing for gas. The result is a toxic gas fatality.

Causal factor determination would commence with the deficiencies in the organization's culture whereby: resources were not provided to replace a defective detection and alarm system in a critical area; staffing decisions resulted in inadequate maintenance; and excessive risk taking was condoned. The employee's violation of the established procedure was a contributing factor, but not principle among several factors.

Heinrich's theory that an unsafe act is the sole cause of an accident is not supported in the cited examples. Also, note that Heinrich's focus on man failure is singular in the following citation: "In the occurrence of accidental injury, it is apparent that man failure is the heart of the problem; equally apparent is the conclusion that methods of control must be directed toward man failure" (H-7). [Note: Heinrich does not define man failure. In making the case to support directing efforts toward controlling man failure, he cites personal factors such as unsafe acts, using unsafe tools and willful disregard of instruction.]

A directly opposite view is expressed by Deming (1986). Deming is known for his work in quality principles, which this author finds comparable to the principles required to achieve superior results in safety.

The supposition is prevalent throughout the world that there would be no problems in production or service if only our production workers would do their jobs in the way that we taught. Pleasant dreams. The workers are handicapped by the system, and the system belongs to the management. (p. 134)



Of all Heinrich's concepts, his thoughts on accident causation, expressed as the 88-10-2 ratios, have had a significant effect on the practice of safety, and have resulted in the most misdirection. Why is this so? Because when based on the premise that man failure causes the most accidents, preventive efforts are directed at the worker rather than toward the operating system in which the work is performed.

Many safety practitioners operate on the belief that the 88-10-2 ratios are soundly based and, as a result, focus their efforts on reducing so-called man failure rather than attempting to improve the system. This belief also perpetuates because it is the path of least resistance for an organization. It is easier for supervisors and managers to be satisfied with taking superficial preventive action, such as retraining a worker, reinstructing the work group or reposting the standard operating procedure, than it is to try to correct system problems.

Certainly, operator errors may be causal factors for accidents. However, consider Ferry's (1981) comments on this subject:

We cannot argue with the thought that when an operator commits an unsafe act, leading to a mishap, there is an element of human or operator error. We are, however, decades past the place where we once stopped in our search for causes.

Whenever an act is considered unsafe we must ask why. Why was the unsafe act committed? When this question is answered in depth it will lead us on a trail seldom of the operator's own conscious choosing. (p. 56)

If, during an accident investigation, a professional search is made for causal factors beyond an unsafe act, such as through the five-why method, one will likely find that the causal factors built into work systems may be of greater importance than an employee's unsafe act. Fortunately, a body of literature has emerged that recognizes the significance of causal factors which originate from decisions made above the worker level. Several are cited here.

### Human Errors Above the Worker Level

Much has been written about human error. Particular attention is given to the *Guidelines for Preventing Human Error in Process Safety* (CCPS, 1994). Although process safety appears in the title, the first two chapters provide an easily read primer on human error reduction. The content of those chapters was largely influenced by personnel with plant- or corporate-level safety management experience.

Safety practitioners should view the following highlights as generic and broadly applicable. They advise on where human errors occur, who commits them and at what level, the effect of organizational culture and where attention is needed to reduce the occurrence of human errors. These highlights apply to organizations of all types and sizes.

- It is readily acknowledged that human errors at the operational level are a primary contributor to the failure of systems. It is often not recognized,

however, that these errors frequently arise from failures at the management, design or technical expert levels of the company (p. xiii).

- A systems perspective is taken that views error as a natural consequence of a mismatch between human capabilities and demands, and an inappropriate organizational culture. From this perspective, the factors that directly influence error are ultimately controllable by management (p. 3).

- Almost all major accident investigations in recent years have shown that human error was a significant causal factor at the level of design, operations, maintenance or the management process (p. 5).

- One central principle presented in this book is the need to consider the organizational factors that create the preconditions for errors, as well as the immediate causes (p. 5).

- Attitudes toward blame will determine whether an organization develops a blame culture, which attributes error to causes such as lack of motivation or deliberate unsafe behavior (p. 5).

- Factors such as the degree of participation that is encouraged in an organization, and the quality of the communication between different levels of management and the workforce, will have a major effect on the safety culture (p. 5).

Since "failures at the management, design or technical expert levels of the company" affect the design of the workplace and the work methods—that is, the operating system—it is logical to suggest that safety professionals should focus on system improvement to attain acceptable risk levels rather than principally on affecting worker behavior.

Reason's (1997) book, *Managing the Risks of Organizational Accidents*, is a must-read for safety professionals who want an education in human error reduction. It has had five additional printings since 1997. Reason writes about how the effects of decisions accumulate over time and become the causal factors for incidents resulting in serious injuries or major damage when all the circumstances necessary for the occurrence of a major event fit together. This book stresses the need to focus on decision making above the worker level to prevent major accidents. Reason states:

Latent conditions, such as poor design, gaps in supervision, undetected manufacturing defects or maintenance failures, unworkable procedures, clumsy automation, shortfalls in training, less than adequate tools and equipment, may be present for many years before they combine with local circumstances and active failures to penetrate the system's layers of defenses.

They arise from strategic and other top-level decisions made by governments, regulators, manufacturers, designers and organizational managers. The impact of these decisions spreads throughout the organization, shaping a distinctive corporate culture and creating error-producing factors within the individual workplaces. (p. 10)

Heinrich's 300-29-1 ratios have been depicted as a triangle or a pyramid.

## Figure 1 Foundation of a Major Injury



*Note.* Adapted from *Industrial Accident Prevention: A Scientific Approach* (1st ed.) (p. 91), (2nd ed.) (p. 27), (3rd ed.) (p. 24), (4th ed.) (p. 27), by H.W. Heinrich, 1931, 1941, 1950, 1959, New York: McGraw-Hill.

The traditional occupational safety approach alone, directed largely at the unsafe acts of persons, has limited value with respect to the “insidious accumulation of latent conditions [that he notes are] typically present when organizational accidents occur.” (pp. 224, 239)

If the decisions made by management and others have a negative effect on an organization’s culture and create error-producing factors in the workplace, focusing on reducing human errors at the worker level—the unsafe acts—will not address the problems.

Deming achieved world renown in quality assurance. The principle embodied in what is referred to as Deming’s 85-15 rule also applies to safety. The rule supports the premise that prevention efforts should be focused on the system rather than on the worker. This author draws a comparable conclusion as a result of reviewing more than 1,700 incident investigation reports. This is the rule, as cited by Walton (1986): “The rule holds that 85% of the problems in any operation are within the system and are the responsibly of management, while only 15% lie with the worker” (p. 242).

In 2010, ASSE sponsored the symposium, Rethink Safety: A New View of Human Error and Workplace Safety. Several speakers proposed that the first course of action to prevent human errors is to examine the design of the work system and work methods. Those statements support Deming’s 85-15 rule. Consider this statement by a human error specialist [from this author’s notes]:

When errors occur, they expose weaknesses in the defenses designed into systems, processes, procedures and the culture. It is management’s responsibility to anticipate errors and to have systems and work methods designed so as to reduce error potential

and to minimize severity of injury potential when errors occur.

Since most problems in an operation are systemic, safety efforts should be directed toward improving the system. Unfortunately, the use of the terms *unsafe acts* and *unsafe conditions* focuses attention on a worker or a condition, and diverts attention from the root-causal factors built into an operation.

Allied to Deming’s view is the work of Chapanis, who was prominent in the field of ergonomics and human factors engineering. Representative of Chapanis’s writings is “The Error-Provocative Situation,” a chapter in *The Measurement of Safety Performance* (Tarrants, 1980). Cha-

panis’s message is that if the design of the work is error-provocative, one can be certain that errors will occur in the form of accident causal factors. It is illogical to conclude in an incident investigation that the principal causal factor is the worker’s unsafe act if the design of the workplace or the work methods is error-inviting. In such cases, the error-producing aspects of the work (e.g., design, layout, equipment, operations, the system) should be considered primary.

U.S. Department of Energy (1994) describes the management oversight and risk tree (MORT) as a “comprehensive analytical procedure that provides a disciplined method for determining the systemic causes and contributing factors of accidents.” The following reference to “performance errors” is of particular interest.

It should be pointed out that the kinds of questions raised by MORT are directed at systemic and procedural problems. The experience, to date, shows there are a few “unsafe acts” in the sense of blameful work level employee failures. Assignment of “unsafe act” responsibility to a work-level employee should not be made unless or until the preventive steps of 1) hazard analysis; 2) management or supervisory direction; and 3) procedures safety review have been shown to be adequate. (p. 19)

Each of these more recent publications refutes the premise that unsafe acts are the primary causes of occupational accidents.

### Heinrich’s Data Gathering & Analytical Method

Heinrich recognized that other studies on accident causation identified both unsafe acts and unsafe conditions as causal factors with almost equal frequency. Those studies produced results different from the 88-10-2 ratios. For example, the *Accident*

*Prevention Manual for Industrial Operations: Administration and Programs, 8th edition* (NSC, 1980) contains these statements about studies of accident causation:

Two historical studies are usually cited to pinpoint the contributing factor(s) to an accident. Both emphasize that most accidents have multiple causes.

- A study of 91,773 cases reported in Pennsylvania in 1953 showed 92% of all nonfatal injuries and 94% of all fatal injuries were due to hazardous mechanical or physical conditions. In turn, unsafe acts reported in work injury accidents accounted for 93% of the nonfatal injuries and 97% of the fatalities.

- In almost 80,000 work injuries reported in that same state in 1960, unsafe condition(s) was identified as a contributing factor in 98.4% of the nonfatal manufacturing cases, and unsafe act(s) was identified as a contributing factor in 98.2% of the nonfatal cases. (p. 241)

Although aware that others studying accident causation had recognized the multifactorial nature of causes, Heinrich continued to justify selecting a single causal factor in his analytical process. Heinrich's data-gathering methods force the accident cause determination into a singular and narrow categorization. The following paragraph is found in the second through fourth editions. It follows an explanation of the study resulting in the formulation of the 88-10-2 ratios. "In this research, major responsibility for each accident was assigned either to the unsafe act of a person or to an unsafe mechanical condition, but in no case were both personal and mechanical causes charged" (H-8).

Heinrich's study resulting in the 88-10-2 ratios was made in the late 1920s. Both the relationship of a study made then to the work world as it now exists and the methods used in producing it are questionable and unknown. As to the study methods, consider the following paragraph, which appears in the first edition; minor revisions were made in later editions.

Twelve thousand cases were taken at random from closed-claim-file insurance records. They covered a wide spread of territory and a great variety of industrial classifications. Sixty-three thousand other cases were taken from the records of plant owners. (H-9)

The source of the data was insurance claims files and records of plant owners, which cannot provide reliable accident causal data because they rarely include causal factors. Nor are accident investigation reports completed by supervisors adequate resources for causal data. When this author provided counsel to clients in the early stages of developing computer-based incident analysis systems, insurance claims reports and supervisors' investigation reports were examined as possible sources for causal data. It was rare for insurance claims reports to include provisions to enter causal data.

This author has examined more than 1,700 incident investigation reports completed by supervisors and investigation teams. In approximately 80% of those reports, causal factor information was inadequate. These reports are not a sound base from which to analyze and conclude with respect to the reality of causal factors.

### Summation on the 88-10-2 Ratios

Heinrich's data collection and analytical methods in developing the 88-10-2 ratios are untransportable. Heinrich's premise, that unsafe acts are the primary causes of occupational accidents, cannot be sustained. The myth represented by those ratios must be dislodged and actively refuted by safety professionals.

An interesting message of support with respect to avoiding use of the 88-10-2 ratios comes from Krause (2005), a major player in worker-focused behavior-based safety:

Many in the safety community believe a high percentage of incidents, perhaps 80% to 90%, result from behavioral causes, while the remainder relate to equipment and facilities. We made this statement in our first book in 1990. However, we now recognize that this dichotomy of causes, while ingrained in our culture generally and in large parts of the safety community, is not useful, and in fact can be harmful. (p. 10)

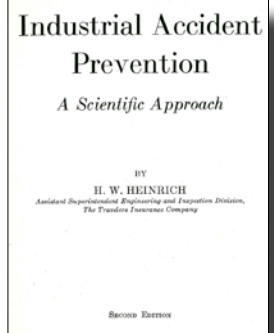
### The Foundation of a Major Injury: The 300-29-1 Ratios

Heinrich's conclusion with respect to the ratios of incidents that result in no injuries, minor injuries and a major lost-time case was the base on which educators taught and many safety practitioners came to believe that reducing accident frequency will achieve equivalent reduction in injury severity. The following statement appears in all four editions of his text: "The natural conclusion follows, moreover, that in the largest injury group—the minor injuries—lies the most valuable clues to accident causes" (H-10).

The following discussion and statistics establish that the ratios upon which the foregoing citation is based are questionable and that reducing incident frequency does not necessarily achieve an equivalent reduction in injury severity. Heinrich's 300-29-1 ratios have been depicted as a triangle or a pyramid (Figure 1). In his first edition, Heinrich writes:

Analysis proves that for every mishap resulting in an injury there are many other accidents in industry which cause no injuries whatever. From data now available concerning the frequency of potential-injury accidents, it is estimated that in a unit group of 330 accidents, 300 result in no injuries, 29 in minor injuries, and 1 in a major or lost-time case. (H-11)

In the second edition, "similar" was added to the citation: "Analysis proves that for every mishap, there are many other similar accidents in industry . . ." (H-12).



Heinrich's study resulting in the 88-10-2 ratios was made in the late 1920s. Both the relationship of a study made then to the work world as it now exists and the methods used in producing it are questionable and unknown.

Data on the trending of serious injuries and workers' compensation claims contradict the premise that focusing on incident frequency reduction will equivalently achieve severity reduction.

**Table 2**  
**Injury Reduction Categories**

Value of claim	Declines in frequency
Less than \$2,000	34%
\$2,000 to \$10,000	21%
\$10,000 to \$50,000	11%
More than \$50,000	7%

*Note.* Data from "State of the Line," by National Council on Compensation Insurance, 2005, Boca Raton, FL: Author.

Within a chart displaying the 300-29-1 ratios in the first edition, Heinrich writes, "The total of 330 accidents all have the same cause." Note that cause is singular (H-13). This statement, that all 330 incidents have the same cause, challenges credulity. Also, note that the sentence quoted in this paragraph appears only in the first edition. It does not appear in later editions (H-14).

For background data, Heinrich says in the first, second and third editions:

The determination of this no-injury accident frequency followed a *most interesting and absorbing study* [italics added]. The difficulties can be readily imagined. There were few existing data on minor injuries—to say nothing of no-injury accidents. (H-15)

In the fourth edition, published 28 years after the first edition, the source of the data is more specifically stated:

The determination of this no-injury accident frequency followed a *study of over 5,000 cases* [italics added]. The difficulties can be readily imagined. There were few existing data on minor injuries—to say nothing of no-injury accidents. (H-16)

The credibility of such a revision after 28 years must be questioned. In Heinrich's second and third editions, major changes were made in his presentation on the ratios, without explanation.

1) The statement in the first edition that the 330 accidents all have the same cause was eliminated.

2) In the second edition, changes were made indicating that the unit group of 330 accidents are "similar" and "of the same kind" (H-17).

3) In the third edition, another significant addition is made. The 330 accidents now are "of the same kind and involving the same person" (H-18).

The following appears in the third and fourth editions, encompassing the changes noted.

Analysis proves that for every mishap resulting in an injury there are many other similar accidents that cause no injuries whatever. From data now available concerning the frequency of potential-injury accidents, it is es-

timated that in a unit group of 330 accidents *of the same kind and involving the same person* [italics added], 300 result in no injuries, 29 in minor injuries and 1 in a major or lost-time injury. (H-19)

These changes are not explained. If the original data were valid, how does one explain the substantial revisions in the conclusions eventually drawn from an analysis of it? In the second, third and fourth editions, Heinrich gives no indication of other data collection activities or of other analyses. How does one support using the ratios without having explanations of the differing interpretations Heinrich gives in each edition?

The changes made in the 300-29-1 ratios in the second and third editions, and carried over into the fourth edition, present other serious conceptual problems. To which types of accidents does "in a unit group of 330 accidents of the same kind and occurring to the same person" apply? Certainly, it does not apply to some commonly cited incident types, such as falling to a lower level or struck by objects.

For example, a construction worker rides the hoist to the 10th floor and within minutes backs into an unguarded floor opening, falling to his death. Heinrich's ratios would give this person favorable odds of 300 to 330 (10 out of 11) of suffering no injury at all. That is not credible.

Consider the feasibility of finding data in the 5,000-plus cases studied to support the ratios, keeping in mind that incidents are to be of the same type and occurring to the same person.

- If the number of major or lost-time cases is 1, the number of minor injury case files would be 29 and the number of no-injury case files would be 300.

- If the number of major or lost-time cases is 5, the number of minor injury case files would be 145 and the number of no-injury case files would be 1,500.

- If the number of major or lost-time cases is 10, the number of minor injury case files would be 290 and the number of no-injury case files would be 3,000.

Because of the limitations Heinrich himself imposes, that all incidents are to be of the same type and occurring to the same person, it is implausible that his database could contain the information necessary for analysis and the conclusions he drew on his ratios. Particularly disconcerting is the need for the database to contain information on more than 4,500 no-injury cases ( $300 \div 330 \times 5,000$ ). Unless a special study was initiated, creating files on no-injury incidents would be a rarity.

Given this, one must ask, did a database exist upon which Heinrich established his ratios, then stated the premises that the most valuable clues for accident causes are found in the minor injury category? This author thinks not.

**Statistical Indicators: Serious Injury Trending**

Data on the trending of serious injuries and workers' compensation claims contradict the



premise that focusing on incident frequency reduction will equivalently achieve severity reduction. The following data have been extracted from publications of the National Council on Compensation Insurance (NCCI, 2005; 2006; 2009).

- In 2006, NCCI produced a 12-minute video, *The Remarkable Story of Declining Frequency—Down 30% in the Past Decade*. It shows that workers' compensation claim frequency was down considerably in the decade cited. The video tells a remarkable but not well-known story.

- A July 2009 NCCI bulletin, "Workers' Compensation Claim Frequency Continues Its Decline in 2008." The reduction was 4.0%. A May 2010 NCCI report says that the cumulative reduction in claims frequency from 1991 through 2008 is 54.7%.

- A 2005 NCCI paper, "Workers' Compensation Claim Frequency Down Again," states, "There has been a larger decline in the frequency of smaller lost-time claims than in the frequency of larger lost-time claims." Also, consider that NCCI (2005) reports reductions in selected categories of claim values for the years 1999 and 2003, expressed in 2003 hard dollars (Table 2).

While the frequency of workers' compensation cases is down, the greatest reductions are for less serious injuries. The reduction in cases valued from \$10,000 to \$50,000 is about one-third of that for cases valued at less than \$2,000. For cases valued above \$50,000, the reduction is about one-fifth of that for the less costly and less serious injuries. The data clearly show that a comparable reduction in injury severity does not follow a reduction in injury frequency.

A DNV (2004) bulletin is another resource of particular note. It states that managing operations to reduce frequency will not equivalently reduce severity.

### What about the pyramid?

Much has been said over the years about the classical loss control pyramid, which indicates the ratio between no loss incidents, minor incidents and major incidents, and it has often been argued that if you look after the small potential incidents, the major loss incidents will improve also.

The major accident reality however is somewhat different. What we find is that if you manage the small incidents effectively, the small incident rate improves, but the major accident rate stays the same, or even slightly increases.

### Contradictions: Unsafe Acts & Injuries

Heinrich's texts contain contradictions about when a major injury would occur and the relationship between unsafe acts and a major injury. In all editions, reference is made to 330 careless acts or several hundred unsafe acts occurring before a major injury occurs, as in the following examples from the first and third editions.

- "Keep in mind that a careless act occurs approximately 300 times *before* [italics added] a seri-

ous injury results and that there is, therefore, an excellent opportunity to detect and correct unsafe practices before injury occurs" (H-20).

- "Keep in mind that an unsafe act occurs several hundred times *before* [italics added] a serious injury results" (H-21).

*Before* is a key word here. While an unsafe act may be performed several times before a particular accident occurs, that is not the case in a large majority of incidents which result in serious injury or fatality. In his fourth edition, Heinrich gave this view of the relationship of unsafe acts or exposures to mechanical hazards.

If it were practicable to carry on appropriate research, still another base therefore could be established showing that from 500 to 1,000 or more unsafe acts or exposures to mechanical hazards existed in the average case before even one of the 300 narrow escapes from injury (events-accidents) occurred. (H-22)

There is a real problem here. All of those unsafe acts or exposures to mechanical hazards take place before even one accident occurs. That is illogical.

### Summation on the 300-29-1 Ratios

Use of the 300-29-1 ratios is troubling. Since the ratios are not soundly based, one must ask whether the ratios have any substance. Does their use as a base for a safety management system result in a concentration of resources on the frequent and lesser significant while ignoring opportunities to reduce the more serious injuries?

One of Heinrich's premises is that "the predominant causes of no-injury accidents are, in average cases, identical with the predominant causes of major injuries, and incidentally of minor injuries as well." This is wrong. It is a myth that must be dislodged from the practice of safety.

Applying this premise leads to misdirection in resource application and ineffectiveness, particularly with respect to preventing serious injuries. In this author's experience, many incidents resulting in serious injury are singular and unique events, with multifaceted and complex causal factors, and descriptions of similar incidents are rare in the historical body of incident data. Furthermore, all hazards do not have equal potential for harm. Some risks are more significant than others. That requires priority setting.

### Misinterpretation of Terms

Not only have many safety practitioners used the 300-29-1 ratios in statistical presentations, but many also have misconstrued what Heinrich intended with the terms *major injury*, *minor injury* and *no-injury accidents*. Some practitioners who cite these ratios in their presentations assume that a "major injury" is a serious injury or a fatality. In each edition, Heinrich gave nearly identical definitions of the accident categories to which the 300-29-1 ratios apply. This is how the definition reads in the fourth edition.

In the accident group (330 cases), a major in-



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## INDUSTRIAL ACCIDENT PREVENTION

A Scientific Approach

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**Heinrich emphasized improving an individual worker's performance, rather than improving the work system established by management. That is not compatible with current knowledge.**

jury is any case that is reported to insurance carriers or to the state compensation commissioner. A minor injury is a scratch, bruise or laceration such as is commonly termed a first-aid case. A no-injury accident is an unplanned event involving the movement of a person or an object, ray or substance (e.g., slip, fall, flying object, inhalation) having the probability of causing personal injury or property damage. The great majority of reported or major injuries are not fatalities or fractures or dismemberments; they are not all lost-time cases, and even those that are do not necessarily involve payment of compensation. (H- 20)

These definitions compel the conclusion that any injury requiring more than first-aid treatment is a major injury. When these definitions were developed in the late 1920s, few companies were self-insured for workers' compensation. On-site medical facilities were rare. Insurance companies typically paid for medical-only claims and for minor and major injuries. According to Heinrich's definitions, almost all such claims would be considered major injuries. Then, is it not so that every OSHA recordable injury is a major injury in this context?

Heinrich's 300-29-1 ratios have been misused and misrepresented many times as well. For example, a safety director recently said that in the previous year his company sustained one fatality and 30 OSHA days-away-from-work incidents, and, therefore, Heinrich's progression was validated. Not so. All of the injuries and the fatality would be in the major or lost-time injury category.

In another instance, a speaker referred to Heinrich's 300-29-1 ratios and said that the 300 were unsafe acts, the 29 were serious injuries and the 1 was a fatality. These are but two examples of the many misuses of these ratios.

### Heinrich's Premises Versus Current Safety Knowledge

Heinrich emphasized improving an individual worker's performance, rather than improving the work system established by management. That is not compatible with current knowledge. Unfortunately, some safety practitioners continue to base their counsel on Heinrich's premises, which narrows the scope of their activities as they attempt principally to improve worker performance. In doing so, they ignore the knowledge that has evolved in the professional practice of safety. A few examples follow:

- Hazards are the generic base of, and the justification for the existence of, the practice of safety.
- Risk is an estimate of the probability of a hazard-related incident or exposure occurring and the severity of harm or damage that could result.
- The entirety of purpose of those responsible for safety, regardless of their titles, is to manage their endeavors with respect to hazards so that the risks deriving from those hazards are acceptable.
- All risks to which the practice of safety applies derive from hazards. There are no exceptions.

- Hazards and risks are most effectively and economically avoided, eliminated or controlled in the design and redesign processes.

- The professional practice of safety requires consideration of the two distinct aspects of risk:

- 1) avoiding, eliminating or reducing the probability of a hazard-related incident or exposure occurring;

- 2) reducing the severity of harm or damage if an incident or exposure occurs.

- Management creates the safety culture, whether positive or negative.

- An organization's culture, translated into a system of expected behavior, determines management's commitment or lack of commitment to safety and the level of safety achieved.

- Principal evidence of an organization's culture with respect to occupational risk management is demonstrated through the design decisions that determine the facilities, hardware, equipment, tooling, materials, processes, configuration and layout, work environment and work methods.

- Major improvements in safety will be achieved only if a culture change takes place, only if major changes occur in the system of expected behavior.

- While human errors may occur at the worker level, preconditions for the commission of such errors may derive from decisions made with respect to the workplace and work methods at the management, design, engineering or technical expert levels of an organization.

- Greater progress can be obtained with respect to safety by focusing on system improvement to achieve acceptable risk levels, rather than through modifying worker behavior.

- A large proportion of problems in an operation are systemic, deriving from the workplace and work methods created by management, and can be resolved only by management. Responsibility for only a relatively small remainder lies with the worker.

- While employees should be trained and empowered up to their capabilities and encouraged to make contributions with respect to hazard identification and analysis, and risk elimination or control, they should not be expected to do what they cannot do.

- Accidents usually result from multiple and interacting causal factors that may have organizational, cultural, technical or operational systems origins.

- If accident investigations do not relate to actual causal factors, corrective actions taken will be misdirected and ineffective.

- Causal factors for low-probability/high-consequence events are rarely represented in the analytical data on incidents that occur frequently, and the uniqueness of serious injury potential must be adequately addressed. However, accidents that occur frequently may be predictors of severity potential if a high energy source was present (e.g., operation of powered mobile equipment, electrical contacts).

As this list demonstrates, Heinrich's premises are not compatible with current knowledge.

## Recommendations

Safety professionals should ensure that the Heinrich misconceptions discussed in this article are discarded by the profession. To achieve this, each safety professional should:

- Stop using or promoting the premises that unsafe acts are the primary causes of accidents and that focusing on reducing accident frequency will equivalently reduce injury severity.
- Actively dispel these premises in presentations, writings and discussions.
- Politely but firmly refute allegations by others who continue to promote the validity of these premises.
- Apply current methods that look beyond Heinrich's myths to determine true causal factors of accidents.

## Conclusion

As knowledge has evolved about how accidents occur and their causal factors, the emphasis is now properly placed on improving the work system, rather than on worker behavior. As one colleague who is disturbed by safety professionals who reference Heinrich premises as fact, says, "It is borderline unethical on their part."

This article has reviewed the origin of certain premises that have been accepted as truisms by many educators and safety practitioners, and how they evolved and changed over time; it also examined their validity. The two premises discussed here are wrongly based and cannot be sustained by safety practitioners. The premises themselves and the methods used to establish them cannot withstand a logic test. They are myths that have become deeply embedded in the practice of safety and safety professionals must take action to dislodge them. **PS**

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## Acknowledgment

Parts of this article are updated material from three of the author's works: *Heinrich Revisited: Truisms or Myths*; chapter seven in *On the Practice of Safety* (3rd ed.); and the article, "Serious Injuries and Fatalities: A Call for a New Focus on Their Prevention," from the December 2008 issue of *Professional Safety*.