Behavior-Based Safety, the Right Long-term approach to address Workplace Safety

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Abstract. Until the present, addressing the behavioral aspects of work-related accidents and occupational diseases in Romania has been very sporadic. Most companies have adopted various programs and initiatives to enhance compliance with Occupational Safety and Health procedures. All these procedures are important for a successful safety process. Done correctly, they contribute to good safety performance. But today, these elements define the average safety effort, representing what everyone else is doing. If a company performs them well, it will achieve an average level of safety for their industry. While the injury rate will be affected by the consistency of these efforts, the result will basically be a normal variation above and below the industry average: some years better than average, some years worse. In this context, the paper presents some tools developed worldwide to improve consistently the safety and health of the employees. The basic objective of this study is to explore the human dynamics of occupational health and safety and to show how these can be managed to significantly improve performance. The principles and practical procedures are not based on common sense or intuition, but rather on reliable scientific investigations. Many recommendations seem different from traditional approaches to occupational safety.

1 Introduction

The International Labor Organization estimates that around 2.3 million women and men around the world die every year from work-related accidents or occupational diseases, which corresponds to more than 6,000 deaths every day. Worldwide, there are around 340 million occupational accidents and 160 million occupational disease fatalities each year. The International Labor Organization updates these estimates every few years, and the updates show an increase in the number of accidents and occupational diseases [1]. The NSC estimates that in 2020, the total cost of workplace injuries was $163.9 billion. The cost per worker in 2020 was $1,100. This includes the value of goods or services each worker must produce to offset the cost of workplace injuries. It does not represent the average cost of a workplace injury. If non-economic damages are quantified and added, such as pain and

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suffering experienced by workers and their families, diminished ability to fulfill family and social roles, impact on family relationships, and diminished morale of co-workers, the cost of workplace accidents and fatalities will be much higher than estimated by the NSC [2].

All deaths from unintentional injuries are preventable, but historically there has been insufficient progress in reducing the number of such deaths. After surpassing deaths from stroke in 2013 and chronic lower respiratory diseases in 2016, unintentional injuries are now the fourth leading cause of death after heart disease, cancer and COVID-19. In order to reduce the enormous cost to society, as well as to minimise human suffering, previous efforts until the 1980s focused primarily on technical action and scientific management of occupational safety [3, 4, 5].

Those injury prevention activities were based, in principle, on a belief in the discrete etiology of accidents - unsafe actions and unsafe conditions.Because the way employees are injured differs so dramatically, prevention strategies must address a multitude of different circumstances. Thus, critically examining and redefining industrial safety research to improve its long-term and widespread impact has important implications for reducing morbidity and mortality and improving the quality of workers' lives [9, 10]. As such, relevant theories of behavioral analysis and social cognitive psychology have been used in research to critically evaluate the long-term impact of interventions designed to improve safe behavior [6, 7, 8].

Safety professionals, team leaders and workers today are struggling to find the best safety approach for their workplace. Usually, whatever offers the cheapest "quick fix." is preferred by them and this is not surprising. The programs that offer the most benefits with the least effort sound the best, but the question is whether they will really work to improve job safety in the long run. It is assumed that humans are responsible for most accidents and injuries, usually through mental errors caused by anxiety, attitude, fear, stress, personality, or emotional states [11]. Accident reduction was usually attempted through "readjusted" attitude or personality, usually through counseling or supervisor discipline [12].

A so-called "*psychological approach*" claimed that certain people were "*accident prone*". By removing the workers from risky jobs or disciplining them to correct their attitude or personality problems, it was expected that the work-related accidents could be reduced. This focus on accident proneness has not been effective, partly because reliable and valid measurement procedures are not available. Also, the factors contributing to this accident proneness are probably not consistent characteristics or traits of people, but vary from time to time and from situation to situation. Employees can ignore a safety procedure and still be injured very rarely. The overall frequency of unsafe acts remains too high, and incidents involving serious injury continue at a statistically predictable rate. New scientific research confirms the effectiveness of a behavioral approach to workplace safety which increases compliance and significantly reduces workplace injuries. This paper presents the type of results that can be achieved through a behavioral approach to safety, a summary of the key components of a behavioral safety process, and an overview of procedures for implementing a behavioral approach within an organization's existing safety efforts. Occupational Safety and Health professionals frequently suggest that addressing the human aspects of occupational safety and health requires only "*common sense*". This is absurd because common sense relies on selective listening of people and is usually based on what sounds good to the individual listener, not necessarily on what works. Even if certain conclusions based on empirical observations by specialists in various fields have been proven correct, scientific research has been the basis for any sustainable change over time. Thus, in contrast to empiricism, systematic and scientific observation allows for the kind of objective feedback needed to know what works and what doesn't, in order to improve behavior. The emergence of a specific behavior can be observed and objectively measured before and after the implementation of an intervention process. Workplace safety should focus on much more

than the behaviors like "*using personal protective equipment*", more than "*isolating and locking out a power supply*" and more than "*maintaining good housekeeping*". Work safety should be an unwritten rule, a social norm, which workers are expected to follow regardless of the situation. It should become a core value of the organization, never questioned - never compromised [13].

When workplace safety procedures are consistently followed and workers' behavior is attributed to a voluntary decision, employees begin to think more safely. Eventually, working safely becomes part of their values system. Values and culture are the most difficult to measure reliably and the hardest to influence directly. This concept of Behavior-Based Safety is providing specific behavior management techniques to promote attitudes and values which supports workplace safety (Figure 1).

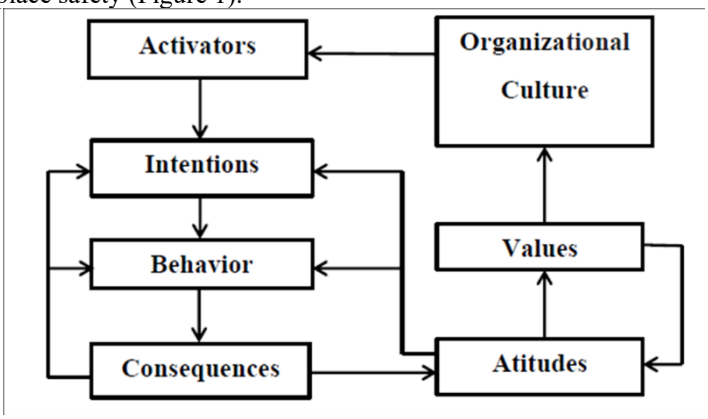

Fig. 1 Influence of behaviour change interventions

Behaviour-based approaches to occupational safety focus on systematically studying the effects of various interventions by first defining the target behaviour in a directly observable and recordable way. The behaviour is then observed and recorded in its natural setting. When a stable baseline measure of the frequency, duration or rate of the behaviour is obtained, an intervention is implemented to change the behaviour in beneficial directions. This intervention usually involves changing the relevance of the antecedents and/or consequences of the specified target behaviour(s). To determine the effectiveness of the intervention, the frequency, duration, or rate of the target behaviour, the behaviour is recorded during and/or after the intervention and compared to measures of the baseline behaviour [14 -16]. Changes in the desired direction are indicative of gaining the target behaviours.

One of the main tools used to influence behaviour in a BBS process is observation and feedback. Feedback can be based on individual or group performance. It can be provided publicly or privately and is often combined with an education or training programme . The literature on behaviour change has shown consistent benefits of displaying or communicating information about risky behaviours to individuals, groups and whole communities [17].

2 The dimensions of human nature. Real vs. perceived risk

The factors that contribute to a workplace injury can be classified into three areas.

- Environmental factors;
- Personal factors;
- Behavioural factors.

This is the "**Safety Triad**" by Geller depicted in Figure 2 [18]. The most common response to an injury is to correct something to the work environment-modify or repair equipment, tools, cleaning, or an environmental hazard. Often the incident report includes a

mention of personal factors such as the employee's knowledge, skills, abilities, intelligence, motives, or personality. These factors are usually translated into general recommendations.

- *"The employee will be disciplined."*
- *"The employee will be retrained."*

Fig. 2. Geller Safety Triad

This kind of superficial attention to the critical human aspects of a workplace accident shows how frustrating and difficult it is to manage the psychology of occupational safety - the personal and behavioral aspects of the Safety Triad. The human factors that contribute to workplace injuries are indeed complex, often unpredictable and uncontrollable. This justifies the conclusion that not all injuries are preventable. The behavior-based approach of applied psychology is grounded in the behavioral science conceptualized and researched by B.F. Skinner [19]. In his experimental analysis of behavior, Skinner rejected unobservable factors such as self-esteem, intentions, and attitudes for scientific study. He investigated only observable behaviour and its social, environmental and physiological determinants. The behaviour-based approach begins by identifying observable behaviours targeted for change and environmental conditions or contingencies that can be manipulated to influence the target behaviour(s) in desired directions. Contingencies are the relationships between designated target behaviours and their supporting consequences. People are generally unimpressed by safety risks or hazards in the workplace. Experiences from the workplace make us perceive a relatively low level of risk (see Table 1).

Table 1. Traits of lower/higher risk perception, adapted from Sandman, 1993,[20]**).**

Lower Risk	***Higher Risk***
• *Exposure is voluntary*	• *Exposure is mandatory*
• *Hazard is familiar*	• *Hazard is unusual*
• *Hazard is forgettable*	• *Hazard is memorable*
• *Hazard is cumulative*	• *Hazard is catastrophic*
• *Collective statistics*	• *Individual statistics*
• *Hazard is understood*	• *Hazard is unknown*
• *Hazard is controllable*	• *Hazard is uncontrollable*
• *Hazard affects anyone*	• *Hazard affects vulnerable people*
• *Preventable*	• *Only reductable*
• *Consequential*	• *Inconsequential*

It's a little odd since it's quite likely that someone will be injured on the job when we consider the number of hours workers are exposed to various hazards. As each day goes by

without an injury, or even a potential incident, we become more convinced of the common belief, "*it won't happen to me*."

The actual risk associated with a particular hazard or behaviour is determined by the magnitude of the loss if an incident occurs and the likelihood that the loss or accident will actually occur. For example, the risk resulting from driving during a trip can be estimated by calculating the probability of a car accident in a single trip and multiplying this value by the magnitude of injury in an accident. Of course, the potential injury or fatality rate from a car accident is influenced by many other factors, including the size of the vehicle(s) involved, the speed of the vehicle(s), road conditions and whether the occupants of the vehicle were wearing seat belts.

On any trip, the chance of a car accident is minuscule; however, in a lifetime of driving the probability is quite high, ranging from 0.30 to 0.50 depending on factors such as geographic location, trip frequency and duration, and driver characteristics such as age, gender, reaction time, or mental state [21]. Clearly, the risk of driving is difficult to assess, although it has been estimated that 55% of all deaths and 65% of all injuries would have been prevented if a 3-point seat belt had been used [22].

3 The DO IT Process

E. Scott Geller is a behavioral psychologist and currently a professor of psychology at Virginia Tech. For few decades, he has taught applications of the behavior-based approach to industrial safety with the acronym depicted below. The process is continuous and involves the following four steps.

- **D:** Define the critical target behavior(s) that you are seeking to increase or decrease.
- **O:** Observe the target behavior(s) during a pre-intervention baseline period to set behavior change goals and perhaps to understand natural environmental or social factors influencing the target behavior(s).
- **I:** Intervene to change the target behavior(s) in desired directions.
- **T:** Test the impact of the intervention procedure by continuing to observe and record the target behavior(s) during the intervention program.

From the data obtained in the testing phase, you can evaluate the impact of your intervention and make an informed decision whether to continue, implement another strategy or define another behaviour that targets the DO IT process. First, what are clear and concise definitions of target behaviors? This is the first objective in the DO IT process. There are so many to choose from: Using equipment safely, lifting properly, isolating power sources properly, and caring for the safety of others, to name a few. Behavioral outcomes such as wearing personal protective equipment, working in a clean and organized environment, and using a vehicle seat belt can also be targeted.

If two or more people independently obtain the same frequency of behavior records when observing the defined behavior or behavioral outcome over the same time period, you have a sufficient definition for an effective DO IT process. Before implementing an intervention program, baseline observations of the target behavior should be made and recorded. The intervention phase involves one or more behavior change techniques based on the simple ABC model described in Figure 3.

As discussed, the activators' direct behavior and consequences motivate the behavior. For example, a telephone or doorbell activates the need for certain behaviors on the part of residents, but residents respond or do not respond to the intercom or door depending on current motives or expectations developed from previous experiences.

Activator →	***Behavior*** →	***Consequence***
Discussion/ Consensus	*Drive the Speed Limit*	*Feedback*
Lecture/Film	*Buckle up*	
Policy	*Lock Out power*	
Demonstration	*Wear PPE*	*Positive or Negative*
Pledge Signing	*Use equipment guards*	
Incentive	*Give a safety talk*	
Disincentive	*Clean up spill*	*Reinforcer or Punisher*
	Remind others to work safely	

Fig. 3. The ABC model used to develop behavior change interventions

3.1 Defining target behaviors

The DO IT process starts by defining the critical behaviors to focus on. These behaviors then become the targets of our intervention strategies. Some target behaviors might be safe behaviors that we want to see more of, such as lifting with bent knees, cleaning a work area, wearing personal protective equipment or replacing machine guards. Other target behaviors may be risky behaviors that need to be reduced in frequency, such as misusing tools, shunting a safety switch, stacking materials incorrectly, and so on. A DO IT process can define desirable behaviors to be encouraged or undesirable behaviors to be corrected. Critical behaviors that should be targeted and identified are:

- At-risk behaviors that have led to a substantial number of potential incidents or injuries in the past and safe behaviors that could have prevented these incidents.
- At-risk behaviors that could contribute to an injury (or fatality) and safe behaviors that could prevent such an injury.

3.2 Observing behaviors

The "SOON" acronym depicted in Figure 4 explores the key aspects of developing appropriate definitions of the critical behaviors that should be pursued in a DO IT process.

Specific • *Concise Behavioral Definition* • *Unambiguous*
Observable • *Overt Behaviors* • *Countable and Recordable*
Objective • *No Interpretation* • *Nor Attributions* • *"What" not "Why"*
Naturalistic • *Normal Interaction* • *Real-world activity*

Fig. 4. Key aspects of critical behaviors

We are ready for the observation phase when we have a list of critical behaviors with specific, observable, objective and naturalistic definitions. A very important feature of '*observable*' behaviors is that they must be quantifiable. In other words, observers of a target behavior should be able to translate their experience into a form that can be objectively

considered and compared with other observations. Some significant aspects (or properties) of the target behavior should be recorded systematically so that changes (or improvements) in behavior can be monitored over time. To do this, we need to consider various properties of the behavior.

While the use of the checklists translates education into training through systematic observation and feedback, the real value of the process is the interpersonal coaching that takes place. In other words, we learn not to get too hung up on the actual numbers. After all, there is a lot of room for error in the statistical game. Rather, we learn to appreciate that through this process people are actively caring for each other's safety and health in a way that can really make a difference. We also learn that even experienced people can perform risky behavior without even realizing it (Figure 5).

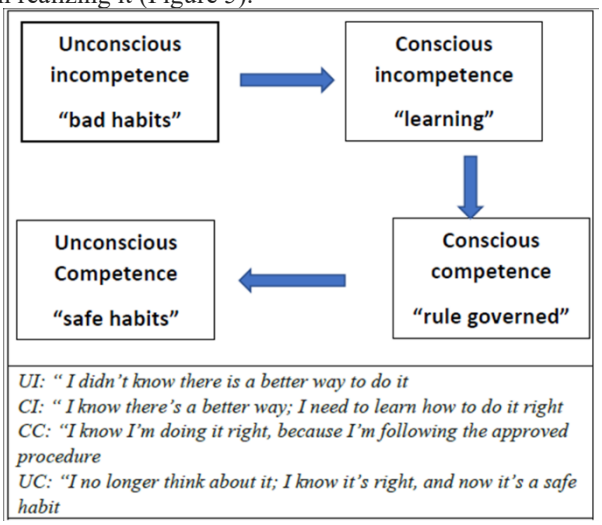

Fig. 5. The DO IT process enables shifts from bad to good habits

4 Basic approaches in the use of Critical Behavioral Checklists(CBC's)

The examples of the Critical Behavior Checklist described here illustrate the basic way of implementing the Define and Observe stages of the DO IT process (Figure 6).

Observer:	***Date:***	
Target Behavior	**Safe**	**At-Risk**
Load appropriate		
Hold close		
Use Legs		
Move feet – Don't twist		
Smooth Motion – don't jerk		
Comments (Use back if necessary):		
% Safe Observations: $\frac{Total\ Safe\ Observations}{Total\ Safe\ Observations+At-risk\ Observations}$X100=_____%		

Fig. 6. A Critical Behavioral Checklist(CBC) used to increase safe lifting

The Critical Driving Behaviors Checklist illustrates the observation and feedback process recommended by a number of behavior-based safety consultants [23]. We refer to this

approach as one-on-one job safety coaching because it involves an observer using a list of critical behaviors to provide instructional behavioral feedback to another person [24, 25].

Another approach involving the Define and Observe stages of the DO IT process involves a limited checklist (probably targeting a single behavior) and does not necessarily involve one-to-one coaching. This is the approach used in most published studies of behavior-based coaching. This is the approach used in most studies of the behavior-based approach to job security (e.g. see reviews by Sulzer-Azaroff et al, 1980, 2005) [26, 27].

In a 1984 study by Geller, he taught this specific approach to HSE leaders at 110 different Ford Motor Company plants [28, 29]. Vehicle seat belt use in all Ford plants increased from 8% to 54%, and this behavior change in 1984 alone saved the lives of at least 8 employees and spared about 400 others from serious injury. Corporate cost savings were estimated at $10 million in the first year and cumulatively at $22 million by the end of 1985.

The concept of sampling the range of behaviors in the target area is essential to the behavior-based safety process. Once the inventory of critical safety-related behaviors is introduced into the organizational culture, on-site staff trained in observation use the behavioral inventory to provide verbal feedback to their colleagues. In this way, observers change and improve the percentage of safe behaviors. Instead of blaming and fault-finding behaviors, the behavior-based approach identifies safety-critical work-related behaviors, measures their impact and manages their frequency. This includes analyzing all occurrences of at-risk behaviors and developing action plans to improve safety performance.

5 Conclusions

The protocol of the BBS interventions reported in the research literature varies dramatically, limited demonstrations or discussions of long-term behavior change were found throughout the literature. For example, no research report documented a transition from formal to informal behavioral observations and feedback, as advocated by Geller and Veazie [30]. Although we are aware of several companies that have continued a successful BBS process for several years, the long-term effectiveness of BBS is not reported in the research literature. We do have firsthand information of the long-term impact of one BBS process as described below.

At the 2014 annual safety conference sponsored by Safety Performance Solutions, the six facilitators of a behavioral-safety process for the 1,500 employees of an oil-drilling company in southern California reported annual results of their observation-and feedback process which was initiated in 1997. Specifically, these individuals showed graphs of man hours, reported injuries, and total recordable injury rates (TRIR) per year for nineteen consecutive years. As depicted in table 1, annual man hours did not vary significantly over this time, but the number of reported injuries and TRIR decreased rather successively and dramatically after a peer-to-peer BBS coaching process was initiated in 1997. TRIR is a measure of the rate of recordable workplace injuries, normalized per 100 workers per year, and is derived by multiplying the number of recordable injuries in a calendar year by 200,000 (100 employees working 2,000 hours per year) and dividing this value by the total man hours actually worked in the year. The BBS process coaching facilitators who reported the impressive long-term outcome data in Table 2 indicated the following as key to their remarkable success:

(a) teaching all employees the procedures and the rationale of these procedures;

(b) maintaining open relationships with the field workers and keeping them in mind at every level of our efforts;

(c) promoting interpersonal trust and the theme that behavioral observation and feedback occurs for the benefit of all employees; and

(d) validating employee ownership of the BBS coaching process by making it visible that workers' peers are involved in every aspect of BBS safety, from training new employees, upgrading and refining materials and procedures, and analyzing and interpreting the results from the CBCs.

Table 2. Annual outcome results from a company that has sustained peer-to-peer BBS observation-and-feedback since 1997.

Year	Number of Man Hours	Number of injuries	TRIR
1995	2,750,000	82	6.26
1996	2,900,000	80	5.47
1997	3,100,000	71	4.41
1998	3,000,000	50	3.35
1999	2,500,000	53	3.86
2000	3,000,000	60	3.99
2001	2,950,000	39	2.64
2002	2,500,000	28	2.22
2003	2,500,000	24	1.94
2004	2,600,000	21	1.62
2005	2,750,000	30	2.21
2006	2,850,000	23	1.06
2007	2,900,000	21	1.43
2008	3,200,000	19	1.16
2009	2,300,000	8	0.68
2010	2,800,000	11	0.78
2011	3,200,000	13	0.79
2012	3,900,000	10	0.52
2013	4,400,000	13	0.59

The popularity of analyzing and summarizing the CBC data with computer assisted technology is significant because it often leads to excessive focus on the data sheet checkmarks in lieu of constructive peer-to-peer feedback conversations about the observed behaviors and conditions that put people at risk for personal injury. Geller and Veazie noted this deviation from an optimal application of the CBC. They claim the primary purpose of formal observation and feedback sessions is not to obtain behavioral data for a computer program, but rather to give employees practice at talking to each other about their safe versus at risk behavior under certain circumstances. It's hoped such formal behavioral observation and feedback communication will lead to daily informal coaching for workplace safety, eventually resulting in a "*Actively Caring*" culture in which employers continually look out for the safety of themselves and others with an interdependent mind set. The evolution to a culture in which workers "have each other's back" is impossible if supervisors conduct the behavioral observations, and this is often the case because it's efficient at getting data for a computer program and does not require costly education and training of the line workers. Too often, even the work supervisors do not receive the necessary education to understand the research-based principles underlying a behavioral observation-and-feedback process. Nor do they receive proper training on how to complete a CBC and deliver behavioral feedback, so it's accepted and appreciated by the individual observed. Most published reports of a BBS process indicate that employee training was a component of the intervention, but the nature of the training is rarely specified.

Indeed, it's likely that many of the BBS consultants from around the world are not even aware of the applied behavioral science (ABS) foundation of BBS, as reviewed in most of the peer reviewed literature on this topic. As a result, they present incomplete and narrow

perspectives of BBS. Too often they offer a quick-fix, step by step behavior-change program rather than the ABS philosophy and principles from which a behavior improvement process can be customized for a particular concern, circumstance, context, and culture.

References

1. ILO, https://ilostat.ilo.org/topics/safety-and-health-at-work/
2. Seo D.C., Safety Science, **43**, 187-211. (2005)
3. A. R. Hale, J. Hovden, Management and Culture: The Third Age of Safety. A Review of Approaches to Organizational Aspects of Safety, Health and Environment. In A. R. Hale, & J. Hovden (Eds.), Occupational Injury: Risk, Prevention and Intervention (pp. 129-165). Boca Raton, FL: CRC Press, (1998)
4. H.W. Heinrich, *Industrial Accident Prevention: a Scientific Approach,* (Mc Graw-Hill, 4ème édition, New York, USA, 1959)
5. D. Petersen, *Analyzing Safety Performance,* (Garland STPM Press, 1996)
6. E. S. Geller, J. of Social Issues, **51**, 179-195. (1995)
7. D. Petersen, Professional Safety, 45(3), 37-41, (2000)
8. U.S. Department of Labor, Bureau of Labor Statistics, National Longitudinal Survey of Youth cohort, 1997-2017 (rounds 1-18), (1997)
9. R.I. Moraru, G.B. Băbuţ, Quality - Access to Success, **11**(4), 50-59, (2010)
10. L.I. Cioca, R.I. Moraru, G. Băbuţ, Proceedings of the Int. Conf. on Risk Management, Assessment and Mitigation (RIMA '10), 56-61, WSEAS Press, (2010)
11. M. Guarnieri, J. Safety Research **23**(3), 151-158, (1992)
12. E. S. Geller, Ind. Safety and Hygiene News, 39(2). p. 12. (2005)
13. D. Zohar, G. Luria, J. Safety Research, **34**, 567-577, (2003)
14. A. Daniels, A. , *Performance Management*. (Tucker, G: Performance Management Publications, 1989)
15. A. Daniels, *Bringing Out the Best in People: How to Apply the Astonishing Power of Positive Reinforcement,* (Third Edition, McGraw-Hill, 2016)
16. E. S. Geller, Professional Safety, **39**(9), 18-24. (1994)
17. D. Zohar, J. Safety Research, **12**, 78 – 85, (1980)
18. E. S. Geller, Professional Safety, **44**(4), 16-19, (1999)
19. B. F. Skinner, *Beyond Freedom and Dignity*, (New York: Alfred A. Knopf, 1971)
20. PM. Sandman, *Responding to community outrage: strategies for effective risk communication.* (New York: AIHA Press, 1993)
21. L. Evans, *Traffic Safety and the Driver,* (Science Serving Society, March 1, 2004)
22. T.R. Krause, *Employee-driven Systems for Safe Behavior.* (Van Nostrand Reinhold, New York, 1995)
23. T.E. McSween, *The values-based safety process: Improving your safety culture with behaviorbased safety* (Second Edition, New Jersey, Wiley-Interscience, 2003)
24. E. S. Geller, D. S. Roberts, M.R. Gilmore, J. Safety Research, **27**, 1-8, (1996).
25. E. S. Geller, Professional Safety, **40**(7), 16-22. (1995).
26. B. Sulzer-Azaroff, M. de Santamaria, J. Appl. Behav. Analysis, **13**(2), 287-295, (1980)
27. B. Sulzer-Azaroff, J. Austin, Professional Safety, **45**(7), 19-24. (2005)
28. E. S. Geller, *The Psychology of Safety Handbook.* (Boca Raton, Fla: CRC Press, 2001)
29. E.S. Geller, Professional Safety, **45**(5), 38-41, (2000)
30. E.S. Geller, B. Veazie, *The Motivation to Actively Care: How You Can Make it Happen,* (Morgan James Publishing, 2020)