

Information HIERARCHY OF CO

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WHEN DESIGNING WORKPLACE TRAINING related to OSH topics, chances are that a safety professional will include or at least mention the hierarchy of controls concept. This training almost always includes a diagram of the model to explain the concept.

As part of best practices in workplace training, the OSH professional is likely to use andragogy (the practice of teaching adult learners) and adult learning principles to help ensure that the worker understands why this subject has immediate relevance to their job and to encourage self-directed learning through problem-solving around relevant tasks (Culatta, 2024; Knowles et al., 2020). One model that may help the OSH professional develop self-directed training that realistically transfers to the workplace is the situation-evaluation-decision-action (SEDA) model (Thalheimer, 2018).

The authors use the SEDA model framing to introduce the situation of the hierarchy of controls diagram, evaluate the effectiveness of the diagram for training on

control methods using information design principles, determine whether the diagram is effective, then recommend actions to improve the diagram that may increase its ability to demonstrate the concept of hazard control methods during worker training.

Situation: The Hierarchy of Controls Diagram

NIOSH (2023) describes the hierarchy of controls concept as “a way of determining which actions will best control exposures” with “five levels of actions to reduce or remove hazards.” NIOSH also notes that employers should “correctly train workers and supervisors on how to use controls.” One common version of the hierarchy of controls diagram was developed by NIOSH as an inverted pyramid with five color-coded levels, with elimination at the top as the most effective method of control, and PPE at the bottom as the least effective method of control (Figure 1). This diagram, or similar versions thereof, is often used as part of OSH

training on hazard control methods. However, whether the diagram effectively conveys this concept brings up several questions that must be addressed:

- 1) Which versions of the diagram do workers most commonly encounter during training?
- 2) Does the information conveyed reflect recommended OSH best practices?
- 3) Does the design of the diagram lead to potential confusion or misapplication?
- 4) Does the diagram use effective information design principles?
- 5) Are there better options for visualizing this concept?

This article answers these questions and evaluates the effectiveness of the hierarchy of controls diagram using best practices for information and message design.

Evaluation of the Diagram

It is unknown exactly how many versions of the hierarchy of controls diagram exist; a cursory search of “safety hierarchy of controls training” yields dozens of versions. However, the most represented version appears to use an inverted pyramid (Figure 1). Many other common versions appear to be adaptations of this classic version in that they retain the pyramid shape and include control levels in a hierarchy.

Versions where the hierarchy of controls concept has been integrated with other safety concepts also tend to retain the use of a pyramid to display multiple levels of control. For example, NIOSH (2020) has developed a version in which the hierarchy of controls concept is applied to the Total Worker Health approach. In this version, the information is still organized in an inverted pyramid with five levels much like the “classic” model. However, each level is adapted to a Total Worker Health approach.

The inverted pyramid design is used in a similar fashion by OSHA (2023), WorkSafe BC (2023), the Canadian Center for Occupational Health and Safety (2023), and the Chemical Hazard and Alternatives Toolbox (ChemHAT; n.d.). As part of the visual display, the ChemHAT diagram contains instructional language at the top of the diagram to “apply the highest level of control commensurate with the risk level—lower value controls may be used in the interim until long-term controls are implemented.” On the left side, an arrow pointing upward toward “elimination” indicates “increasing effectiveness and sustainability,” and on the right side an arrow pointing downward toward “PPE” indicates “increasing participation and supervision needed” (ChemHAT, n.d.).

KEY

TAKEAWAYS

- OSH professionals often introduce workers to the hierarchy of controls concept during workplace training.
- The commonly used hierarchy of controls diagram may need revisions to improve its efficacy and usability as a tool to help workers learn to identify, assess, prevent, and control hazards and risks on the job.
- An improved diagram for use in training on the control methods concept should be based on information design principles to aid worker comprehension.

Design in the CONTROLS DIAGRAM



Although the use of a pyramid appears to be the most common way to demonstrate the hierarchy of controls, a few examples such as Safe Crane (2016) and OSH Academy (2019) use a ladder diagram to display six control levels instead of a pyramid. Figure 2 (p. 26) shows an example of this kind of hierarchy of controls diagram. In this case, the ladder steps are separated into hazard controls and exposure controls. Three steps of the ladder are grouped under hazard controls:

- 1) eliminate: remove the hazard from the workplace,
- 2) substitute: replace the hazard with a safer alternative, and
- 3) isolate: isolate the hazard using engineering controls to prevent workers from coming into contact with them.

The other three steps of the ladder are grouped under exposure controls:

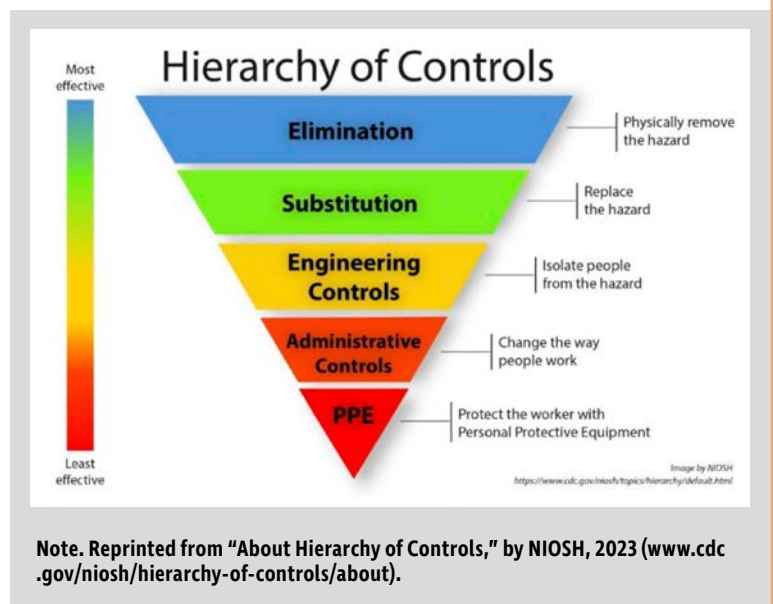
- 4) warning: or promote awareness of workplace hazards,
- 5) administrative: manage how work is organized or practiced, and
- 6) PPE: wear protection after considering all other options.

Despite the many different versions of the hierarchy of controls diagram that are used for training purposes, they all appear to have some similarities. Specifically, some similarities exist in the language used, the emphasis on more effective or reliable controls, and the addition of clarifying or instructional language to help with understanding the technical terminology used.

Decision About Effectiveness

To decide whether the hierarchy of controls diagram is effective for training purposes, it must be determined if its use encourages information literacy and information competence in those undergoing training. Information literacy requires a range of research and critical-thinking skills to identify information needs, to locate and assess relevant information, and to use the acquired knowledge to meet their needs (ALA, 2024; Pettersson, 2015a). Information competence has a similar definition but also includes ethical and legal dimensions as part of effective communication of the information in multiple forms (Orange Coast College Library, n.d.). Information literacy is one goal of practicing decision-making and task

FIGURE 1
NIOSH HIERARCHY OF CONTROLS DIAGRAM



Note. Reprinted from "About Hierarchy of Controls," by NIOSH, 2023 (www.cdc.gov/niosh/hierarchy-of-controls/about).

competence during workplace training because it allows the worker to use what was learned to perform work tasks successfully through learning transfer (Thalheimer, 2018). In general, a person is considered information-literate if they can access, evaluate and use information in a competent way, such as by formulating questions, evaluating information for accuracy and relevance, organizing information, and using information for problem-solving in real-world scenarios (Pettersson, 2015a).

In the context of the hierarchy of controls diagram, information literacy and competence related to the hazard controls concept might be achieved if a worker successfully identifies a hazard, recalls the hierarchy of controls concept or diagram, assesses which control methods are being used, and recommends alternate or improved control methods based on their knowledge of the facility, equipment in use, and work processes they interact with during their work tasks (OSHA, 2016).

Effective Information Design

Information literacy and competence are facilitated by effective information design. Basic information design principles include ensuring a clear message structure,

using a simple and consistent design, grouping related elements together, and choosing concise language without unnecessary jargon (Pettersson, 2012).

Further, the hierarchy of controls diagram is a form of visual language. Visual language uses content, execution, context and format to influence the perception of the message (Pettersson, 2015b). Consequently, when evaluating visual messages such as the hierarchy of controls diagram, the focus should be on clarity—the words, the contrast between the words and colors, whether the visual contains only essential information, and the use of sequencing to present complex concepts (Pettersson, 2015b).

Limitations of Commonly Used Hierarchy of Controls Diagram Designs

Based on the tenets of effective information design outlined in this article, if the intent of the diagram is to convey that the hierarchy of controls is “a method of identifying and ranking safeguards to protect workers from hazards” (OSHA, 2023) or as a way for employers to “correctly train workers and supervisors on how to use controls” (NIOSH, 2023), there may be a need to improve how the concept is commonly presented.

Firstly, it should be questioned whether the different types of controls should be visualized as a hierarchy at all. Using a hierarchy may not reflect OSHA’s position that there is a requirement to “combine control methods to best protect workers” (2023, p. 1) because the hazard “may need a combination of control methods (e.g., engineering controls plus administrative controls) to provide the best level of protection” (2023, p. 3). Although the term “hierarchy” is included as part of the concept’s namesake, it is possible that OSH professionals may have become so used to calling this concept the “hierarchy of controls” that it has rarely been asked whether the information should even be organized as a hierarchy at all.

Potential Confusion From Users

Beyond the limitations of enforcing a hierarchy, the use of a pyramid design by OSHA, NIOSH and others may cause confusion for OSH professionals and workers. For example, a hierarchy with a pyramid diagram generally

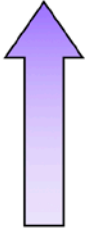
indicates that the top option should be used or selected first, and that it is the best option. In the case of the most commonly used inverted pyramid, the diagram reflects the ideal direction that OSH professionals would prefer organizations to use (i.e., showing the inverted triangle with elimination at the wider portion on top and PPE at the narrow portion on the bottom). In this case, not only is the best option at the top of the diagram, it is also given the most surface area. However, other commonly used versions show the triangle with elimination at the apex of the triangle and PPE at the wider base of the triangle. The common use of both versions may cause confusion regarding which options to select for hazard control methods and lead to misapplication of the concept.

Another factor that may cause confusion for workers is the use of color. Most common diagrams appear to be inspired by NIOSH’s (2023) hierarchy of controls diagram, which uses blue, green, yellow, orange and red. However, the use of these colors does not match the standardized use of colors on safety and health signs and labels seen in the workplace. Signs and labels designed to meet standards such as ANSI Z535.1-2022, Standard for Safety Colors, use these colors to convey specific meanings related to safety communications. For example, red commonly means danger or stop, orange is usually meant to indicate a warning, yellow means caution, green typically denotes safety instructions, and blue signifies notice or information. Using these colors without clear intent can be confusing for the user if the colors conflict with what is experienced in the real world and what is reinforced through safety training (Grainger, 2019). Furthermore, it is unclear whether the colors selected to represent each control level or category are relevant to and supportive of the overall message intended to be conveyed by the hierarchy of controls diagram.

Lastly, the diagrams tend to use substantial OSH and engineering jargon. This language could be simplified to aid user comprehension, improve accessibility and allow for easier translation into other languages for non-English-speaking workers. Options for more accessible language could easily be developed by using one of the simple words used to define the most used control levels.

FIGURE 2 LADDER DIAGRAM EXAMPLE

Example of a hierarchy of controls diagram using a ladder configuration with six levels.

Hazard controls			Effectiveness 
1	Eliminate	Remove the hazard from the workplace.	
2	Substitute	Replace the hazard with a safer alternative.	
3	Isolate	Isolate the hazard using engineering controls.	
Exposure controls			
4	Warning	Promote awareness of workplace hazards.	
5	Administrative	Manage work practices and organization.	
6	PPE	Wear protection after considering all other options.	

Note. Adapted from “Lifting—Hierarchy of Controls,” by Safe Crane, 2016 (www.safecrane.nz/news/lifting-hierarchy-of-controls); and “Introduction to Hazard Controls (Course 122),” by OSH Academy, 2019 (www.oshatrain.org/courses/mods/122m2.html).

•**eliminate**: to completely *remove* or get rid of

•**substitute**: something that takes the *place* of another thing

•**engineer**: to *design* and build something

•**administer**: to *manage* and be responsible for

•**protective**: capable of or intended to *protect*

Given these concerns related to the design and organization of the diagram, use of color and overly technical language, it seems evident that the hierarchy of controls diagram may need to be revised to improve its efficacy and usability as a tool to help workers learn to identify, assess, prevent, and control hazards and risks on the job.

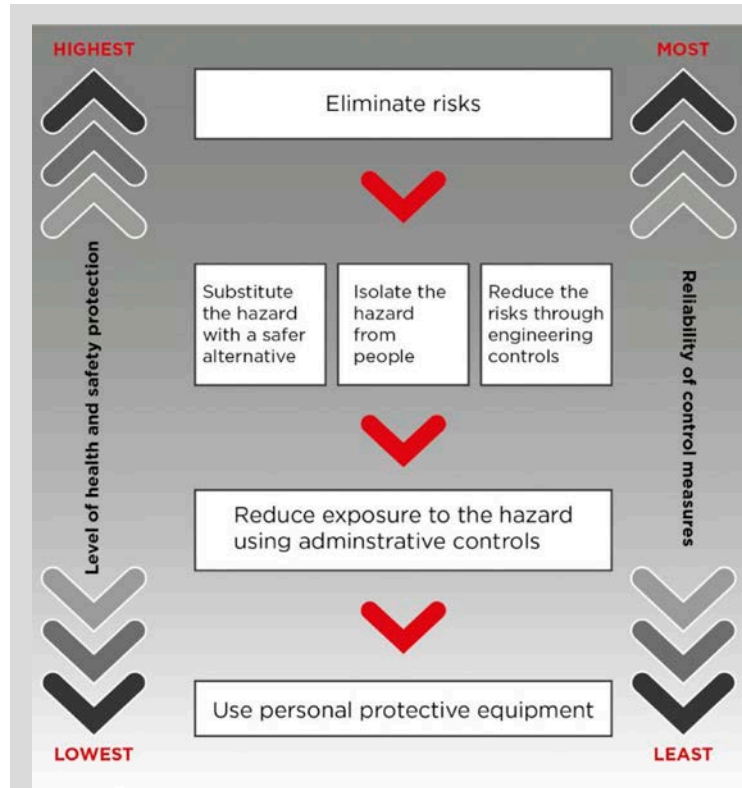
Recommended Changes

Based on this review, many of the hierarchy of controls diagrams, including the most commonly used one promoted by NIOSH and OSHA, do not appear to use best practices for communicating information, effective messaging or image design. This may lead to difficulty in using the diagram to help workers and OSH professionals learn how to determine which actions they should take to control exposures to hazards in the workplace. Therefore, redesigning the control methods concept to ensure that it uses accessible and clear language, consistent colors and a simple self-explanatory structure should be explored.

As noted, one fundamental change to the diagram that may enhance worker understanding of the hazard control concept could involve modifying how the concept and its accompanying diagrams are discussed. Rather than a “hierarchy” of controls, this concept could be referred to as “recommended control methods,” “selecting control layers,” “safeguard layers” or simply “hazard control methods.” Removing the term “hierarchy” allows for the selection of controls or safeguards in a layered manner to ensure adequate worker protection and better communicates that selecting control methods should be part of a hazard and risk assessment process, which better reflects OSHA’s (2023) position that combining control methods is often required to provide the best level of protection.

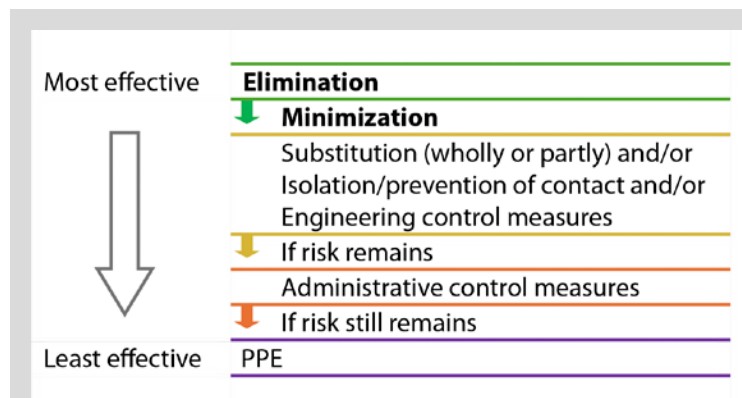
However, this change may also necessitate a move away from the classic pyramid design as this shape reinforces the hierarchical relationship between levels of control. Additionally, the way this shape

FIGURE 3
SAFework AUSTRALIA
HIERARCHY OF CONTROLS DIAGRAM



Note. Reprinted from “Managing Risks,” by SafeWork Australia, n.d. (www.safeworkaustralia.gov.au/safety-topic/managing-health-and-safety/identify-assess-and-control-hazards/managing-risks).

FIGURE 4
WORKSAFE NEW ZEALAND
MODIFIED LADDER DIAGRAM



Note. Adapted from “Risk Management,” by WorkSafe New Zealand/Mahi Haumarua Aotearoa, 2017 (www.worksafe.govt.nz/topic-and-industry/hazardous-substances/managing/risk-management).

forces the placement of the most recommended component at the top and the least recommended component at the bottom may make it difficult to demonstrate how these levels can work together to protect workers. Therefore, an option other than a pyramid such as a waterfall or block diagram, a ladder chart, a timeline, tree diagram, an activity diagram, or a phase diagram or matrix may be required to improve the visualization of this control methods concept. An activity diagram is a type of flow chart that shows how activities or events flow, overlap or otherwise relate to each other as part of a system (Visual Paradigm, 2024), and a phase diagram is used to show how changing variables can affect conditions in a process (ChemTalk, n.d.). Many of these diagram options would be more complex and graphical but may be a better fit for the informational needs of workers.

For example, SafeWork Australia (n.d.) takes a hybrid process and ladder approach to the hierarchy of controls diagram (Figure 3, p. 27). Although this version contains similar information to the NIOSH (2023) diagram and is still hierarchical in nature in that it moves from most effective to least effective controls, it groups substitution, isolation and engineering controls together in the center of the diagram, indicating that these control methods or measures offer similar layers of protection and reliability. Additionally, the use of the arrows that move in both directions indicates that the hierarchy of controls is both a sequential and connected process.

A stronger use of the ladder diagram that encourages thinking of the hierarchy of controls as a connected process rather than as a hierarchy can be seen in the modified ladder diagram version of the hierarchy of controls concept developed by WorkSafe New Zealand/Mahi Haumaru Aotearoa (2017), shown in Figure 4 (p. 27). This version includes additional guidance on managing risk and was created to demonstrate that the selection of controls is a process within risk management that may require multiple levels or types of controls to manage workplace risks effectively. The use of a cycle, pie chart or wheel configuration may even further clarify this concept.

Another advantage to moving away from the standard pyramid version of the model is that some of these alternatives may be better suited to allow other useful concepts to be incorporated into the diagram, such as the anticipation, recognition, evaluation, control and confirmation of controls decision-making framework from industrial hygiene. It should also be explored whether the risk avoidance level of the hierarchy of controls—as is present in ANSI/ASSP Z590.3-2021, Prevention Through Design Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes—should be included in the diagram. As Walline (2014) notes, the risk avoidance level is focused on preventing “the entry of hazards into a workplace by selecting and incorporating appropriate technology and work methods criteria during the design processes” (p. 46).

As discussed, the use of color on most diagrams is another area that must be addressed. Evidence suggests that the consistent use of color-coding schemes (i.e., using existing safety colors with similar meanings) can help the user interpret the new information on the backdrop of their previous experience and training (Pettersson, 2012).

TABLE 1
POSSIBLE LANGUAGE CHANGES, COLORS

Possible language changes and associated colors for revision to control methods diagram.

Existing controls language	Possible change	Possible color
Elimination	Remove	Purple
Substitution	Replace	Blue
Engineering controls	Redesign	Green
Administrative controls: program, policy	Manage	Gray
Administrative controls: Training/procedure	Train	Yellow
Administrative controls: warning, label, sign	Warn	Orange
PPE	Protect	Red

FIGURE 5
VERTICAL OR LADDER PROCESS

Mock-up for control methods diagram revision as a vertical or ladder process.



Therefore, the colors should be changed to better align with standards such as ANSI Z535.1-2022, Standard for Safety Colors, which drives how these colors are used in the safety and health signs and labels employees encounter in their workplaces.

Table 1 outlines suggested changes to the language to promote the use of active, clear and non-jargon terms that do not require additional explanation. Using active voice, clarity, comprehensibility, simplicity, and structure can facilitate both communication and the learning process of

FIGURE 6
ADAPTED LADDER DIAGRAM MOCK-UP

Mock-up for control methods diagram as an adapted ladder diagram with revised language, organization and color scheme.



Hazard control methods		Reliability and protection
1	Remove the hazard from the work environment.	
2	Replace the substance or process to reduce the hazard.	
3	Redesign the process or task to prevent exposure to the hazard.	
Exposure control methods		Most reliable Highest protection  Least reliable Lowest protection
4	Manage the system, policies, programs and work practices.	
5	Train workers about procedures and warnings used.	
6	Warn workers of hazards using signs, alarms and labels.	
7	Protect with PPE and devices.	Lowest protection
Select and combine hazard control and exposure control methods to effectively protect workers.		

FIGURE 7
SIMPLIFIED MOCK-UP, REDUCED LANGUAGE

Simplified mock-up for control methods diagram as an adapted ladder diagram with reduced language.

Hazard control methods		Reliability and protection
1	Remove	
2	Replace	
3	Redesign	
Exposure control methods		Most reliable Highest protection  Least reliable Lowest protection
4	Manage	
5	Train	
6	Warn	
7	Protect	Lowest protection

the user (Pettersson, 2015c). Additionally, by expanding and reordering the existing control method options to align with the level of organizational effort required, it becomes feasible to match them to existing color schemes from OSH signs, labels and standards.

Starting from the least effective control method (Table 1), red indicates danger or stop in OSH practice, and it is consistently applied to PPE as a control method in existing hierarchy of controls diagrams. Orange indicates warning for parts of equipment that can harm workers, so its use is well suited for “administrative controls: warning, label, sign.” Yellow indicates caution, therefore, its use for “administrative controls: training, procedure” could emphasize the need to avoid complacency when developing or receiving OSH training. The use of gray for “administrative controls: program, policy” indicates the managerial and administrative nature of the control method. Green indicates safety instructions, and its use for “engineering controls” indicates the need to involve an OSH professional when designing or redesigning these control options. Blue is used for notices and information, so its use for “substitution” emphasizes the need to continually assess the risks of hazardous substances and equipment on site

and stay informed of available substitutions. Purple is a user-defined color option used for “elimination” and completes the color scheme.

This proposed language clarifies the expectations and actions to be taken, is simpler, and does not require an OSH professional to explain or interpret what each word or phrase means. Figure 5 is a basic mock-up of how the language in Table 1 may be used to design a control methods diagram that retains the model as a simple diagram about control methods with clearer language, the hierarchy de-emphasized, presented more like a process through the use of a shape other than a triangle or pyramid, and includes better use of color that aligns with workplace experience.

However, Figure 5 does not include any additional instructional language or information about the effectiveness of each method. Although it is shown as a vertical or ladder process, it is not clear that multiple control methods may be needed, and the design of the diagram makes it seem as if the user must go through each stage in the process, which may not be applicable to each type of hazard being controlled. Additionally, the design of the diagram does not place particular emphasis on any stage of the process, instead indicating a start point (remove, if possible) and an endpoint (protect if all other options have been tried).

Therefore, instead of a simple diagram like Figure 5, the use of an information graphic that combines the various required information together may be better for training purposes. Information graphics provide the user with a “rapid and easily grasped overall view” of the message to be suitable as an introduction to or summary of a concept (Pettersson, 2015c).

Figure 6 is an adapted version of the ladder diagrams from Safe Crane (2016) and OSH Academy (2019) that is more akin to an information graphic than a simple diagram and incorporates all these principles by using the revised language and color scheme outlined in Table 1.

Having all the information organized and visually grouped into meaningful clusters helps the user chunk and remember the content (Pettersson, 2015c).

Figure 6 (p. 29) provides simpler language with a brief description of each method. It includes OSH Academy's (2019) suggestion that the first three strategies protect workers by eliminating or reducing the hazard itself, whereas the remaining strategies protect workers by reducing exposure to the hazard. Additionally, the inclusion of the reliability and protection elements could help an OSH professional explain why the hazard control methods are more reliable and offer greater protection to workers. The instructional language to select and combine methods is also consistent with guidance from OSHA, NIOSH and others.

Figure 7 (p. 29) is a simplified version of Figure 6, with reduced language that matches Table 1 (p. 28) and the hazard control and exposure control methods chunked together without a description of each method. This is the option most similar to the NIOSH (2023) hierarchy of controls diagram shown in Figure 1 (p. 25). Either Figure 6 or the simpler Figure 7 (p. 29) could be used for workplace training about control method options.

Conclusion

The examples in Figures 6 and 7 (p. 29) are two potential ways that the control methods concept may be better visualized for use during workplace training. When considering the situation and evaluation presented in this article, OSH professionals are encouraged to practice their own decision-making competence and determine whether action is needed to continually improve the way the control methods concept is visualized and used to train workers. Perhaps it is worth asking workers if they struggle with the jargon, inconsistent colors, and organization as a pyramid or hierarchy when trying to apply the concept of control methods to their daily work. Given the various ways that the control methods concept is visualized (as shown in this article), a need exists for more accessible, simpler and easily translatable language to aid in worker comprehension.

Part of evidence-based practice in OSH is adopting and adapting the evidence base gathered from other disciplines, such as information design. Recall the question posed at the beginning of this article: Is the hierarchy of controls an effective way of explaining OSH control methods to workers? The best way to find an answer to this question is to ask the workers. **PSJ**

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