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RESEARCH ARTICLE

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Evaluating the readability and suitability of construction occupational safety and health materials designed for workers

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Introduction: Printed materials for training and hazard communication are an essential part of occupational safety and health programs, but must be understood by their intended audience.

Methods: Researchers collected 103 safety training handouts, brochures, and Safety Data Sheets and scored them for readability and suitability using four standard health communication instruments: the SMOG test, the Flesch-Kincaid Reading Ease Assessment, the SAM (Suitability Assessment of Materials), and CCI (the CDC Clear Communication Index).

Results: Some of the materials used unfamiliar and technical terms. The SAM and CCI checklists revealed several elements of design and layout known to facilitate communication and comprehension, but missing from most of the materials scored.

Conclusion: Occupational safety and health professionals preparing curricula and handouts for distribution to workers should incorporate some form of readability and suitability assessment to help ensure their written materials are clear and comprehensible to all segments of their audience.

KEYWORDS
construction, hazard communication, health communication, health literacy, occupational health, occupational safety, Safety Data Sheets, training

1 | INTRODUCTION

Printed materials are a fundamental building block for occupational safety and health programs. Safety Data Sheets describing hazardous substances are a basic element in OSHA's hazard communication standard. A 2015 CPWR survey of 319 construction safety professionals and safety trainers found that 62% had used handouts or brochures during the previous month.[1]

However, printed materials can only be effective if the intended audience understands their content. The construction labor force is diverse, with a broad range of literacy skills. A substantial fraction of that labor force has low English-language literacy, attributable to limited educational attainment, English as a second language, or other factors. Recent U.S. Census surveys found that more than one out of five construction industry workers (21%) age 25 or over lacked a high school degree, and that more than one in four (26.7%) spoke a language other than English at home.[2,3] The 2003 National Assessment of Adult Literacy found that 23% of construction and extraction workers had "Below Basic" literacy skills, limited to "locating easily identifiable information in short, commonplace prose texts."[4]

Occupational safety and health researchers and practitioners have long recognized the challenges of delivering safety and health education to workers who may have low literacy or limited English capabilities.[5–7] The Material Safety Data Sheets (MSDS) required under OSHA's 1983 Hazard Communication Standard have been a special object of concern. In a notable study, Phillips et al presented MSDSs to 160 trade workers, soliciting their opinions of the sheets and testing their understanding of the content. While more than 90% of the workers expressed satisfaction with the MSDSs, 39% of the

Institution at which the work was performed: CPWR—the Center for Construction Research and Training.

workers said they found the sheets difficult to understand—and in objective tests, the researchers found that workers "did not absorb one third of the information provided on each of the three different MSDSs studied, demonstrating weaknesses in the formats' ability to diffuse information to workers."[8]

Communication researchers have generated a series of tools and instruments to help writers develop clear and simple written materials accessible to readers with a wide range of literacy skills. In the 1960s and 1970s an early generation of educators and communication researchers created "readability formulas" based on sentence and word length that offered a rough and ready estimate of the grade level of education needed to comprehend a particular text.[9,10] Popular formulas from the period, such as the SMOG test and the Flesch-Kincaid Reading Ease Test, are still widely used today. However, their design limits what they can measure—they do not address awkward phrasing, document structure, use of visuals or many other elements that contribute to reader comprehension.

Researchers in health communication, concerned that existing patient education materials were inaccessible to low-literacy adults, built on this foundation. In 1985, Cecelia and Leonard Doak, together with Jane Root, published the first edition of *Teaching Patients with Low Literacy Skills*, which introduced the Suitability Assessment of Materials or SAM.[11] The Doaks considered readability testing important: the SAM scored materials written at the 6th to 8th grade level "adequate" and materials written below the sixth grade level "superior." But the SAM went much further than readability, with a checklist of 22 items that also took into account elements such as use of the active voice, descriptions of clear and specific behaviors, and proper use of subheadings, bullet points, illustrations, and culturally appropriate references. The completed SAM yields an overall score of 1-100 for each material assessed, with materials scored 0-39 rated "not suitable," 40-69 "adequate," and 70-100 "superior."

Today the SAM is still perhaps the most popular instrument of its kind, but researchers have created a number of alternatives, including the Centers for Disease Control and Prevention's "Clear Communication Index" or CCI.[12,13] Writers using the CCI to guide publication design begin by identifying the primary audience and its literacy skills, the communication objective, and their main message. Relying on the answers to these questions, the writer or reviewer answers up to nineteen questions with a "yes" or "no." For instance, rather than specifying a single ideal grade level, the CCI asks, "Does the material always use language the primary audience would use?" The CCI also introduces some new criteria, such as communicating uncertainty ("Does the material explain what authoritative sources know and do not know about the topic?") The answers generate an overall score between 0 and 100. If the material scores 90 or above, it is considered suitable for use with the intended audience. If the material scores 89 or below, the writer is urged to revise the material until it scores 90+.

The past two decades have witnessed an explosion of readability and suitability studies focused on health education materials. Researchers have assessed public health brochures distributed in clinics, health centers, and hospices,[14–16] medication guides included with prescriptions,[17] publications describing widespread medical conditions such as hepatitis, lung cancer or urological disorders[18–20] and those distributed in dozens of practice specialties ranging from pediatrics to ophthalmology.[21–25] The studies almost invariably document continuing issues with the readability and suitability of materials distributed to lay audiences. Wolf et al[17] found that "available med[ication] guides fall below the threshold of acceptable standards for patient print materials"; Ryan et al[15] reported that "healthcare systems continue to develop and use educational materials that are not appropriate for many of the patients and families they serve."

These studies indicate that despite growing awareness of the demand for clearly written and well-designed health education materials accessible to readers at all levels of literacy, and improved tools and techniques to support this, much currently circulating material falls short of these goals. The current study reviews a sample of construction occupational safety and health materials to discover the extent to which they meet established readability and suitability standards.

2 | METHODS AND MATERIALS

The study examined a convenience sample of short handouts or brochures used to inform construction workers about occupational safety and health topics. Most were single-page handouts or folding cards, but a few were as long as six pages. The research team collected 100 printed materials published by the four major groups active in this field: (i) federal government agencies, such as the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH); (ii) state and local government agencies, such as state labor or public health departments; (iii) commercial or for-profit entities, such as construction contractors, professional safety consultants, insurance providers and materials manufacturers; and (iv) non-profit occupational health organizations and associations, including CPWR—the Center for Construction Research and Training (see Figure 1). In addition, the team collected three Safety Data Sheets (successor to the MSDS), produced by construction product manufacturers to comply with OSHA Hazard Communication Standard requirements, which we analyzed separately.

Researchers identified and collected the materials either through internet searches or by contacting publishing organizations directly. In order to exclude materials created for use by managers or safety professionals, the team included only materials *expressly intended* for distribution to workers. Materials expressly intended for workers either directly addressed workers in their text (eg, "**You** must wear gloves when. . ." not "**Workers** must wear gloves when. . .") or were accompanied by instructions stating that they were intended for distribution to workers. The sample contained materials from every region of the country and covered a wide variety of topics, including safety hazards, health hazards, and ergonomic hazards.

For each item in the sample, the research team recorded the title, hazard domain (safety, health, ergonomics, or other), topic, publication year, publisher, and publisher category. Raters used a standard online

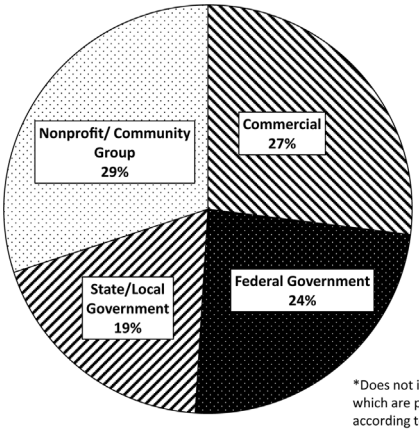

FIGURE 1 Construction safety training material sample by publisher category (n = 100*)

readability calculator (readability-score.com) to evaluate the text, generating grade level equivalents using both the SMOG and Flesch-Kincaid formulas. They then separately rated each of the printed materials for suitability using both the SAM and CCI instruments, with both readers scoring every item in the sample. Finally, they met to review the scores together and reconcile any discrepancies in their scoring. The statistics reported below are based on the reconciled scores.

3 | RESULTS

The aggregate readability and suitability scores are reported in Table 1. The two readability formulas produced similar results for the 100 safety handouts and brochures intended for worker training: the SMOG instrument generated a mean grade level of 7.6 (95%CI: 7.3-8.0), as did the Flesch-Kincaid (95%CI: 7.2-8.1). The SMOG grade levels ranged from 3.6 to 12.5, while the Flesch-Kincaid ranged from 2 to 14.2. The readability tests found that approximately one-third of the construction occupational safety and health materials were written above the 8th grade level (29% using the SMOG test, 39% using Flesch-Kincaid), and that only a small minority were written below the 6th grade level (7% according to the SMOG test, 20% according to Flesch-Kincaid).

The mean SAM score for the materials under study was 74.7 out of 100 (95%CI: 71.2-77.4), with a low of 45 and a high of 98. Sixty-four percent (64%) of the materials were rated superior by the SAM; 36% of the materials were rated adequate; none received a "not suitable" rating.

The scores by SAM item are reported in Table 2. The collected materials demonstrated strength (ie, 80% or more materials scored "superior") on seven of the SAM's 22 items. Most of the handouts limited their scope; employed a conversational style and the active voice; broke long blocks of text or long lists into small chunks, guiding the reader with subheadings and other "road signs"; and chose

TABLE 1 Material scores (n = 100)

	Mean	95% CI	Low	High
SMOG grade level	7.6	7.3-8.0	3.6	12.5
Flesch-Kincaid grade level	7.6	7.2-8.1	2	14.2
SAM score	74.7	71.2-77.4	45	98
CCI score	81.0	79.3-82.7	53	95

TABLE 2 Suitability assessment of materials (SAM) items (n = 100)

SAM item	Materials rated superior (%)	Materials rated adequate (%)	Materials rated not suitable (%)
Match in logic, language, experience	92	8	0
Scope is limited	88	9	3
Type of graphics	85	16	0
Writing style, active voice	84	14	2
Learning aids via "road signs"	82	11	7
Subheads ("chunking") used	80	11	9
List, tables, etc. explained	80	9	11
Typography	77	23	0
Purpose is evident	75	23	2
Vocabulary uses common words	75	23	2
Cover graphic shows purpose	74	25	1
Motivation—self-efficacy	72	24	4
Relevance of illustrations	71	17	13
Behaviors are modeled and specific	71	14	15
Context is given first	68	21	11
Layout factors	66	32	2
Cultural image and examples	62	33	5
Content is about behaviors	51	22	27
Captions used for graphics	48	8	44
Interaction used	26	11	63
Summary or review is included	14	11	75
Reading grade level	7	64	29

TABLE 3 Clear Communication Index (CCI) items (n = 100)

CCI item	Materials scored "Yes" (%)	Materials scored "No" (%)
Explains the nature of risk	99	1
One main message statement	97	3
Main message emphasized with visual cues	97	3
Always uses numbers the primary audience uses	97	3
Main message at top/front	97	3
Organized in chunks with headings	95	5
Contains call to action for primary audience	90	10
Numeric risk probability explained with words or a visual	90	10
Gives specific directions for performing the behavior	89	11
Uses short bulleted or numbered lists	85	15
Does not ask audience to do math	78	22
Contains visual reinforcing main message	76	24
Always uses words that primary audience uses	73	27
Main message and call to action use active voice	72	28
Most important information summarized in first section	71	29
Explains why behavioral recommendation is important for primary audience	64	36
Addresses both risks and benefits of recommended behaviors	57	43
Explains what authorities know and do not know	48	52
Always explains what numbers mean	45	55

culturally appropriate examples and references. In other areas a substantial fraction (or even a majority) of the materials proved deficient, earning a "not suitable" rating: 27% dwelled on general information rather than concrete behaviors and actions audience members could take; 29% were written above an 8th grade level; 44% lacked captions for graphics; 63% did not incorporate any interactive elements to engage the reader; and 75% lacked a summary or review of the key points of the material.

The mean CCI score for the materials was 81.0 out of 100 (95%CI: 79.3-82.7), with a low score of 53 and high score of 95. Only 6% of the materials rated scored 90 or above to earn a "suitable" rating under the CCI; 94% of the materials fell below the CCI threshold.

The scores by CCI item are reported in Table 3. On eight items, more than 90% of the materials met the CCI requirements. They had one main message (97%) presented in the opening segment (97%) and emphasized with visual cues (97%). The text explained the nature of the risk addressed (99%), was broken into chunks with subheadings (95%), gave specific directions for performing the desired behavior (89%), and always used numbers the primary audience would use (97%).

On four items, however, at least 30% of the materials examined failed to meet the CCI requirements. Thirty-six (36%) failed to explain the importance of the recommended behavior for the user; 43% did not explain both the risks and benefits associated with the "call to action" (usually but not always a recommended safety and health behavior). On two items, an absolute majority of the materials failed to meet CCI requirements. The CCI recommends writers explain the "state of the science" (what scientists and technical experts know and do not know about the topic or hazard), but 52% of the materials did not do this. The CCI also calls for writers to explain all numbers used in terms the audience will easily understand—for example, a handout on trench fatalities stated "a cubic yard of soil weighs one ton—about as much as a small car." Fifty-five percent (55%) of the materials did not explain what the numbers meant in this way.

The sample contained construction safety and health materials published by federal government agencies, by state and local government agencies, non-profit or community organizations, and commercial or for-profit actors (see Figures 2 and 3). On average, the materials produced by non-profit and community groups performed best on the readability and SAM tests. State and local government materials ranked second; federal government materials ranked third; commercially produced materials ranked last. The CCI scores of the four groups were clustered much more tightly, but followed a similar pattern, with the nonprofit and community groups earning the highest scores.

A much larger gap divided the Safety Data Sheets from the other materials, with the SDSs scoring somewhat lower on readability and dramatically lower on suitability. The Safety Data Sheets earned a mean SAM score of 36.3 (95%CI: 26.3-46.4), compared to 74.7 (95% CI: 71.2-77.4) for the others. Two out of the three SDSs were rated "not suitable" by the SAM. The mean CCI score for the SDSs was 43 (95%CI: 34-52), compared to 81 for the others (95%CI: 79.3-82.7). Understandably, the Safety Data Sheets often used unfamiliar terms and seldom focused on a single audience or offered a single clear,

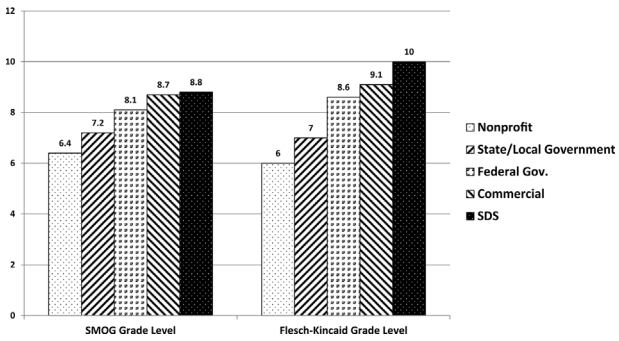

FIGURE 2 Mean readability scores by publisher category

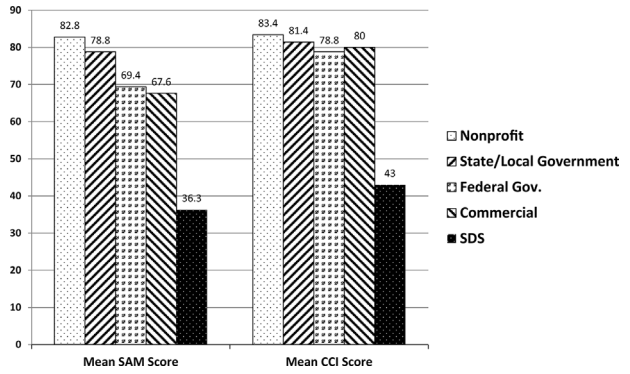

FIGURE 3 Mean suitability scores by publisher category

specific call to action. They also provided little explanatory context for numbers, concepts, and behaviors mentioned in the text.

4 | DISCUSSION

The mean readability test scores of the construction safety and health materials examined here (grade 7.6) exceeded the 6th grade level recommended by Doak et al, and about one-third of the materials scored exceeded the 8th grade level. These findings argue for close attention to the use of simple, clear, and direct writing to make safety and health messages accessible to audience members with literacy constraints. Readability calculators can be a useful tool to alert writers to words and sentences that deserve a second look, but should be used with care. Readability formulas are no substitute for knowing your audience. A writer who removes familiar terms of the trade or relevant cultural references to achieve a lower grade level can make a text less accessible rather than more.

The two suitability tests identified certain areas of strength in the collection of materials. Judging from the sample, few occupational safety and health writers still produce materials for workers containing long unbroken blocks of text. The materials generally contained small chunks of text under descriptive subheadings, and many writers helpfully replaced dense prose paragraphs with short bulleted or numbered lists, making them easier to read and absorb. For construction workers who may read these materials standing on a worksite, rather than seated in a classroom, these elements are essential.

The picture is more mixed with some other key suitability elements. Communication researchers agree that print materials that seek to "do it all" by addressing every audience about every aspect of a topic are less effective than those targeted to a specific audience, tightly focused on a single, specific message for that audience, and containing a clear call to action for that audience. A number of the materials surveyed could have earned higher scores on the SAM and CCI by targeting their content more explicitly to a single audience and message. Written health and safety materials should begin with a summary of their important points that contains the main message, preparing the reader for the supporting material that will follow. They should take care to use words that their primary audience uses and explain any numbers in terms familiar to the target audience.

The two suitability instruments yielded fairly similar raw scores (a mean 74.7 out of 100 for the SAM, and a mean 81.0 out of 100 for the CCI). However, the SAM awards a "superior" rating to any written material with a score of 70 or higher, while the CCI requires materials to achieve 90 or higher for approval—so that while 64% of the materials earned a superior rating from the SAM, only 6% passed the CCI.

This can largely be explained by the CCI's purpose as a tool to guide material designers through an iterative process of improvement. The guide instructs writers, "If the total score is 89 or below: Note which items scored 0 points. Use the descriptions and examples in the User Guide to revise and improve the material. Then apply the Index again to check your work. You can use the Index as many times as you need to revise the material to get a score of 90 or above."

The raters found few examples of one of the CCI criteria: the "state of the science" item, which directs writers to report both what is known and what is *not* known about the topic. Hard experience has sensitized health communications professionals to the need to disclose what authorities *do not* know, as well as what they do, especially in areas of scientific uncertainty or rapidly evolving public health emergencies, and the *CCI User Guide* examples suggest that the item was included with these situations in mind.[13,26–28] The safety training materials, on the other hand, confined themselves to citing long-established facts ("Falls are the leading cause of deaths and injuries in the construction industry") to reinforce basic and uncontroversial safety practices ("Make sure you have level, solid footing for your ladder"). Except in the case of certain emerging hazards, such as a brochure on potential health hazards from engineered nanomaterials in construction, there was little opportunity or need to convey uncertainty.

The suitability testing also helped shed light on past research examining worker use of Safety Data Sheets. In the 1983 Hazard Communication Standard, OSHA required that manufacturers and employers maintain a Material Safety Data Sheet (MSDS) on each hazardous chemical in the workplace, and provide it to workers upon request. Although this was a significant landmark in the "right to know" movement in occupational health, advocates and occupational researchers soon became concerned that many exposed workers found the MSDSs difficult to comprehend and use, even after the required hazard communication training.[6,29] The SAM and CCI tests help explain why this would be the case. Although the MSDSs contained critical information, their prescribed format made it difficult to incorporate many of the communication elements identified in suitability tests. Of necessity they incorporated difficult technical language and scientific terms; they were not targeted to a single audience, but to a wide variety of audiences who might encounter the hazardous substance during its life cycle; they were not restricted to a single call to action, but provided information for personal protection, first aid, toxicology, and dangers of fire and explosion, among other topics.[30]

The new Safety Data Sheets (SDSs) associated with the Globally Harmonized System represent an improvement in some of the areas, but as legally mandated documents required to serve multiple

purposes and audiences, SDS writers cannot adopt evidence-based communications practices such as adapting to the needs of a single target audience or limiting themselves to a single main message. The OSHA webpage on Hazard Communication notes that "In order to ensure chemical safety in the workplace, information about the identities and hazards of the chemicals must be available and understandable to worker."[31] To achieve this in practice, employers must supplement the SDS with occupational safety and health materials targeted to the needs of employees in their workplace and adopting key elements of effective communication. Tools such as readability tests, the SAM, and the CCI can help in this process.

Finally, no readability or suitability test is a substitute for testing written materials with the intended audience. Where resources permit, the ideal method for developing effective health communication materials is an iterative process that incorporates readability and suitability testing, expert reviews, and focus group testing with members of the target audience.[32]

5 | CONCLUSIONS

The construction worker audience contains members with a wide range of literacy skills and educational attainment, and includes many for whom English is a second language. Health communication researchers have identified evidence-based practices that can make occupational safety and health materials more accessible to all audiences, but many writers preparing brochures and handouts used in construction occupational safety and health training today have yet to adopt them. Writers and publishers of occupational safety and health materials can use readability and suitability test instruments to identify opportunities to improve their publications. Such testing should not be seen as a substitute for live testing with members of the intended audience, but as a complement to it.

Today's Safety Data Sheets are an important resource for safety and health management programs, but they are not the best tools to share critical safety information with a worker audience. Workers need targeted materials designed for their needs. For effective hazard communication, employers should supplement the SDS with worker-oriented training materials.

6 | LIMITATIONS

There is no central repository of safety training materials from which to draw a randomized sample. Consequently, while the research team worked to collect a diverse sample of materials, with a variety of authors, publishers, states and regions represented, the results may not be representative of all materials used in occupational safety health and safety training.

AUTHORS' CONTRIBUTIONS

Clayton Sinyai developed the research design, acquired the materials to be tested, and wrote up the draft findings. Brenda MacArthur and Thomas Roccotagliata scored the materials and reviewed the manuscript.

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ETHICS APPROVAL AND INFORMED CONSENT

This project did not rely on human subjects, so was not subject to institutional review.

DISCLOSURE (AUTHORS)

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DISCLOSURE BY AJIM EDITOR OF RECORD

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DISCLAIMER

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