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Toolbox talks to prevent construction fatalities: Empirical development and evaluation

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ABSTRACT

Three studies were conducted to develop and evaluate safety toolbox talks about fatal construction incidents. Study 1 surveyed workers ($n = 28$) about existing pre-shift meetings. An evidence-based structure for toolbox talks was developed, and study 2 evaluated our selected line drawing illustration format with workers ($n = 30$). Study 3 evaluated supervisors' talks using: (1) new toolbox guides and (2) long-form investigation reports with workers from eight construction crews.

In study 1, 25% of the sample reported never conducted safety meetings. In study 2, compared to photos, line drawings increased the distance workers' could correctly identify hazards by over 1.5 m. In study 3, the new format was preferred by 82% of supervisors, saved them 15 min preparation/presentation time, and produced favorable impacts with workers.

Brief scripted toolbox talks made it easier for supervisors to share fatal stories and prevention recommendations with their crews. When the format includes scripted text for the supervisors, prompts for discussion and action items, and line drawings worker understanding can be enhanced.

1. Introduction

Construction is a high-risk industry with dynamic occupational hazards. The work is typically performed at dispersed locations, including multiple job sites or multiple locations within a single job site (Bureau of Labor Statistics, 2014). Industry specializations include, but are not limited to, commercial and residential construction, bridge erection, excavation, demolition, and roadway paving. Common hazards vary by trade, project, and project stage, but include falls from heights, mobile machinery, electrical exposures, falling objects, inclement weather, equipment failure, and structural collapse. The mix of contractors, trades, and workers changes as projects progress and employers must continually adapt to recruit, staff, and communicate with workers at each building stage (Lockyer and Scholarios, 2007). These exposures contribute to elevated occupational fatality rates in construction. Globally it is estimated that 350,000 workers die each year (International Labor Organization, 2014), with 60,000 of these deaths occurring in the construction industry (The National Examination Board in Occupational Safety and Health, 2014). In the US, the current construction industry fatality rate is 9.9 per 100,000 full time workers compared to the average 3.4 rate for all US industries (Bureau of Labor Statistics, 2012). In 2012, the largest proportion (36%) of construction fatalities were due to falls (Bureau of Labor Statistics, 2011).

Controlling hazards and preventing fatal injuries in construction is a multi-faceted challenge. The first priority and best safety control is to completely remove hazards from construction environments. However, when complete hazard removal or control is not possible, training and administrative controls should be applied to promote best safety practices that limit workers' exposures to hazards. In this regard, safety training and communication can set expectations, increase hazard awareness, develop knowledge and skills, and reinforce safe building practices. A traditional communication channel in construction is the safety tailgate or toolbox talk. These brief talks typically address a focused safety

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topic and are delivered by supervisors or safety personnel before work or during breaks.

The current project was designed to develop and evaluate toolbox talk material about fatal construction incidents. This was an outreach research project of the Oregon Fatality Assessment and Control Evaluation (OR-FACE) program (NIOSH Grant U60OH008472), which is one of nine state-based FACE programs funded by the National Institute for Occupational Safety and Health in the United States. The national FACE mission is to "prevent occupational fatalities across the nation by identifying and investigating work situations at high risk for injury and then formulating and disseminating prevention strategies to those who can intervene in the workplace" (Centers for Disease Control and Prevention, 2014a). Research activities of state-based FACE programs include expanded surveillance and assessment of fatal workplace injuries, investigation of selected fatal incidents, and developing and evaluating outreach publications and activities.

Stories and lessons learned from fatal events investigated by FACE programs may provide particularly compelling content for safety toolbox talks. However, traditional FACE investigation reports may not be easily used by supervisors for this purpose (Centers for Disease Control and Prevention, 2014b). These reports are typically 5–10 pages long and provide an in-depth summary of fatality investigations and prevention recommendations. The language in reports is also typically tailored for an audience of safety professionals. While front line supervisors may use investigation reports for toolbox talks, significant reading and preparation time would be required. Briefer toolbox talk guides could save supervisors time and effort and make it easier for them to share fatal stories and lessons learned with their crews. Over the long term, adapting FACE investigation reports into brief toolbox talks could increase the number of construction supervisors who share fatality stories and prevention recommendations with their crews.

1.1. Safety communication and the role of toolbox talks

The quality and frequency of safety communication in the workplace, especially between supervisors and their subordinates, is associated with organizational safety practices and employees shared perceptions of safety priorities, or safety climate. In meta-analysis research, including studies in construction (Gillen et al., 2002), safety climate predicts employee safety compliance, participation, and injuries (Clarke, 2006). Applied experiments provide additional compelling evidence of the positive impacts of supervisor safety communication. Zohar and Luria (2003) implemented an intervention at four non-construction worksites where line supervisors set goals and received feedback for three months about (a) the frequency of their safety-related interactions with their subordinates and (b) levels of safe behavior/conditions in the workplace. Line supervisors also discussed their goals and feedback with their own upper-level managers. This cross-level feedback process for leaders increased the frequency of supervisors' safety-related interactions, safe work practices, and group-level safety climate. The same intervention model was tested in the construction industry. Two groups (four foremen and their crews) received the intervention and three groups (three foremen and their crews) served as controls. As expected, control groups that received no intervention showed no changes over time. One of the two intervention groups showed significant increases in the frequency of supervisors' safety-related interactions and safety climate (Kines et al., 2010).

Toolbox talks are a traditional and potentially impactful form of supervisor safety communication in construction. Toolbox talk materials are in demand and provided by notable construction-oriented organizations (Center for Construction Research and Training, 2014). The demand is likely driven by both perceived utility of the format and government regulations. For example, the Oregon Occupational Safety and Health Administration requires construction employers to hold regular safety meetings or operate a safety committee (Oregon Occupational Safety & Health Administration, 2009). If employers opt for safety meetings, all available employees must attend, and meetings must be held at least once a month and/or at the beginning of any job lasting more than a week. The meetings must include discussions of "safety and health issues [and] accident investigations, causes, and the suggested corrective measures" (p. 113). Therefore, in Oregon and beyond, toolbox talks are an established delivery mechanism for communicating fatality prevention information to many thousands of workers.

Although safety toolbox talks are a common and valued form of safety communication in construction, research evaluating current practices or toolbox talk related interventions are surprisingly scarce. To identify relevant assessment or experimental studies in this area we searched Medline, PsychInfo, Scopus, and Thomson Reuters Web of Science using the search terms: "preplanning meeting*" OR "toolbox talk*" OR "safety meeting*" OR "op* meeting" OR "daily meeting" OR "preshift huddle" OR "toolbox guides" OR "safety communication" AND (occupational or work* or industrial) AND the proximal words – using limiters adj2, pre/2, near/1 – (safety or health or injur$ or accident$ or mortality or incident*). These searches returned hits ranging from 25 to 39 articles across the different databases. A review of abstracts and selected full papers identified nine studies/papers related to the perceived importance, effectiveness, and current quality of toolbox talks (seven studies were construction industry focused), and five articles/sources related to the need for materials and value of real case studies in talks. Among these papers, we identified just one experimental field study evaluating a toolbox talk intervention. Our review of findings from our literature search is provided in the paragraphs below.

Evidence does indicate that toolbox talks are perceived to be important and may be a component of effective safety programs in construction. In California, construction industry stakeholders identified improving toolbox trainings as their highest priority intervention area from among several other options (Harrington et al., 2009). Esmaeili and Hallowell (2012) reviewed seven research studies on components of effective safety programs and identified "project specific training and safety meetings" to be one of 12 consensus effective strategies. In a study of interview data from 28 construction sites, Hinze and colleagues (2013) found that reported "participation of all contractors in safety meetings" was one of 14 differentiating practices associated with reduced recordable injury rates (correlation = −.27, $p = .05$).

Research on current practices suggests that there are opportunities for improving the frequency and quality of safety meetings, including toolbox talks. In a study of safety climate perceptions among Latino residential construction workers (Arcury et al., 2012) only 25% agreed or strongly agreed that workers attend regular safety meetings. Interview and observational research suggests that some types of safety meetings may be mostly management driven and produce little engagement with subcontractors or workers (Mäki and Koskenvesa, 2012). For example, an analysis of scripts from construction site orientation meetings revealed that workers spent 0–2% of the time talking. Similar formal analyses of engagement in weekly safety meetings was not reported, but researchers noted that these meetings tended to be less formal and provide opportunities for some discussion and two-way feedback. Other researchers have recommended safety toolbox talks as a flexible method for safety communication and generating discussion, especially among small contractors (Hung et al., 2011), or as a means for supporting the dissemination and roll out of new engineering or equipment interventions

(Kramer et al., 2009). While there is potential for toolbox talks to be engaging, safety professionals have noted opportunities for improvement (Forck, 2005; Williamsen, 2003). Forck (2005) shared his opinion that "Traditional safety meetings are filled with videos and reading material, all 'hear' and 'see' activities" (p. 2). Methods recommended by safety professionals for improving engagement include asking open-ended questions, hands on practice of actual tasks or procedures, specifying desired outcomes for meetings, and making action plans with accountability and follow-up (Forck, 2005; Williamsen, 2003).

Industry stakeholders have indicated a need for ready to use materials for toolbox talks (Heidotting, 2002) and noted that real world case studies may enhance their impact (CPWR Construction Solutions, 2014; Kaskutas et al., 2013). Further, researchers have indicated that case studies provide opportunities to find the lessons learned from a specific incident and allow workers to discuss contributing factors and what could have been done to prevent the injury (Bajpayee et al., 2004). Telling real stories with prevention recommendations may also enhance the personal relevance of hazards and their consequences. Given the relative rarity of injuries and fatalities, even in high risk industries, many workers will not have personal experience with, or know someone who experienced, a serious work related incident. In this regard, workers may not perceive risk or be motivated to engage in prevention behaviors as they believe (and have observed correctly) that such incidents are rare (Plog et al., 2006). Thus, stories and recommendations from real events may present opportunities to improve the interactivity and personal impact of toolbox talks.

In the single intervention evaluation study identified in our literature search, Harrington et al. (2009) developed and evaluated a program to train construction supervisors in giving more effective toolbox talks. Through formative research, investigators identified four characteristics of effective tailgate (toolbox) talks: (1) the topic fits the job; (2) the crew participates; (3) the supervisor demonstrates what he/she is talking about; and (4) the tailgate leads to action. A four-hour training was developed to model and teach supervisors how to deliver effective talks. Training materials included "Safety Break" cards to help participants, who were predominantly leaders/supervisors, apply what they learned (California Department of Public Health, 2014). Evaluation analyses from the first 18 of 25 training sessions (n = 1195 participants) showed that immediate reactions were favorable with 86% finding the training very helpful. Six months after the training, 335 (32% retention) participants provided valid follow-up surveys, and 78% reported that the effectiveness of their talks had increased or greatly increased. They also shared that they believed that their talks increased workers' frequency of raising safety concerns (38%), attention to company safety rules (54%), and role in solving problems (55%). Supervisors reported that the Safety Break cards were useful or very useful (83%), but some did not use the cards at all (13%). Among 6-month responders were 84 contractors who at baseline reported not being in compliance with California OSHA regulations to give a safety talk every 10 days. At six months, 77% of these contractors (n = 65) reported increasing their tailgate training frequency (although the frequency was not specified).

1.2. Summary, research gap, and purpose of current project

Preventing fatal injuries in construction is a socially important priority. Fatal stories and prevention recommendations in FACE investigation reports include valuable and potentially lifesaving information, but these long-form documents are probably not ideal for helping front line supervisors present the material in safety toolbox talks. Supervisor safety communication, including toolbox talks, is an important dimension of injury prevention efforts and effective safety programs in construction. Surveillance research and opinions from safety professionals, however, suggest there is room for improving the frequency and quality of toolbox talks. The use of real case studies may provide opportunities to enhance interactivity and personal relevance of safety talks. We found just one experimental field study where researchers evaluated a training program to improve the quality of toolbox talks given by construction supervisors (Harrington et al., 2009). While supervisors rated the training favorably and reported a range of positive outcomes six months later, including increased frequency of safety talks among a small subsample, a low percentage of trainees participated in follow-up surveys and no evaluation data were collected from crews. More research and evidence-based outreach is needed to assist supervisors in communicating fatality prevention information to their crews in toolbox talks. To address gaps in research and practice, we engaged with construction and university partners to develop and evaluate evidence-based toolbox talks about fatal construction cases with both supervisors and their construction crews. Project partnerships, toolbox development, and research methods for three field studies with construction workers are described below.

2. Materials, methods, and sub-study results

Research to develop and field test evidence-based guides for toolbox talks took place in three stages. Study 1 was a needs assessment survey conducted with construction supervisors and workers at a regional safety conference. Following study 1, draft one-page guides were developed by students enrolled in a professional safety course using evidence-based safety communication principles. These draft guides were then edited and standardized into a uniform template format by OR-FACE staff before conducting additional field evaluation research in studies 2 and 3. Study 2 compared a line drawing illustration format, selected for the toolbox talks, to standard photographs. Researchers measured workers' preferences and ability to correctly identify features in illustrations that varied by size and type. Eight construction crews participated in study 3 where supervisors prepared and gave two toolbox talks to their crews using the guides in one instance, and then a full fatality investigation report (roughly 5–10 pages) on another instance (order of presentation was counterbalanced). Researchers measured the duration of talks as well as subsequent supervisor and worker reactions, preferences, and behavioral intentions. Procedures for each of the three studies were reviewed and approved by the relevant University human subjects institutional review board.

2.1. Study 1: Needs assessment survey

A needs assessment survey was designed and conducted to inform the overall direction of the project. This survey asked supervisors and workers to report on their current company practices regarding pre-shift meetings (i.e., toolbox talks, tailgate talks, safety meetings) and also asked about their interest in, and preferred format for, toolbox talk content on fatal injury cases.

2.1.1. Study 1: Participants and setting

A convenience sample of construction supervisors and workers was recruited at a regional construction safety conference in the Pacific Northwest region of the US. Participants were approached with the study opportunity as they walked by an exhibit booth sponsored by the Oregon Institute of Occupational Health Sciences. After a brief description of the survey, interested participants provided verbal informed consent and then completed the survey. Participants who completed the survey were entered into a lottery

style drawing for a single $100 incentive (paid for by private donation, and not NIOSH grant funds).

2.1.2. Study 1: Measures

The survey included 12 questions covering demographics (including work experience and company type and size), the frequency of pre-shift meetings at participants' company, and the topics covered in such meetings. The topic options were work planning, timelines/productivity targets, company news/updates, general safety (hazards, personal protective equipment, best practices), or safety stories (about close calls, injuries and/or fatalities). If participants reported that safety was a topic in pre-shift meetings, they were asked how often safety was addressed. The survey concluded with additional questions about their interest in and preferred format for future toolbox material about fatal incidents.

2.1.3. Study 1: Results and discussion

Participants in study 1 ($N = 28$) were predominantly male ($n = 25$) with a mean age of 46.54 years (SD = 9.87). Most participants were white ($n = 25$); other races reported were American Indian/Alaskan Native ($n = 1$), Asian ($n = 1$), and mixed race ($n = 1$). One person reported Hispanic/Latino ethnicity. Participants' roles in their companies varied, and some respondents selected multiple roles, including safety professionals ($n = 10$), managers or supervisors ($n = 6$), employees ($n = 5$), owners ($n = 3$), and other ($n = 6$). Participants worked in residential, commercial, and other types of construction companies that ranged in size from less than 5 to over 1000 employees (median = 58).

Of the 28 workers surveyed, 25% ($n = 7$) reported that their company never conducted pre-shift meetings. Among those reporting meetings ($n = 21$), 19 met at least once per week, and 17 reported addressing safety in meetings at least once per week (Table 1).

The most frequently discussed topics included work planning (pre-task/job plan) and general safety. Only 10 respondents reported that their meetings included safety stories about close calls, injuries, or fatalities (Fig. 1).

Participants identified a range of safety hazards and topics that they deemed important to address. High importance topics mentioned included falls, ladders, elevated working environments, vehicle and driving safety, digging, and paying attention. All of the participants surveyed agreed that if they were provided one-page summaries of Oregon construction fatalities, that they or their supervisors would use them in toolbox talks.

2.2. Development of draft toolbox talks and study 2

The development of a template structure for toolbox talks began as a project in a professional safety course offered for the Portland State University Occupational Health Psychology training program (CDC/NIOSH 5T01 OH008435-08). The course included undergraduate and graduate students and focused on the science and practice of professional safety within the construction industry. The safety director from a regional commercial construction firm provided guest lectures and field experiences, including an observation of a safety toolbox talk at a hospital renovation site. After reading and discussing articles on evidence-based safety communication (Larkin and Larkin, 2007; Wogalter et al., 2002) graduate student-led teams were each assigned one of eight in-depth FACE construction fatality investigation reports to adapt into a toolbox talk. Each investigation report was roughly 5–10 pages long and followed the investigation format of the NIOSH FACE program (Centers for Disease Control and Prevention, 2014b). Each student created their own one-page (double-sided) toolbox talk guide for their assigned case, and were asked to integrate

Table 1
Frequency of pre-shift meetings and safety discussions.

Frequency	Conducts meetings	Discusses safety
Daily	9 (32.1%)	7 (25.0%)
2–4 times/week	2 (7.1%)	1 (3.6%)
1 time/week	8 (28.6%)	9 (32.1%)
2–3 times/month	0 (0.0%)	1 (3.6%)
1 time/month	2 (7.1%)	2 (7.1%)
A few times/year	0 (0.0%)	0 (0.0%)
Never	7 (25.0%)	7 (25.0%)
No response	0 (0.0%)	1 (3.6%)
Total	28 (100%)	28 (100%)

Note: In Oregon, construction employers with 10 or more employees and the majority of staff working on construction sites may have a safety committee or conduct safety meetings. The committee or safety meetings must occur at least once per month, and at the beginning of any new project lasting one week or longer (Oregon Occupational Safety & Health Administration, 2009).

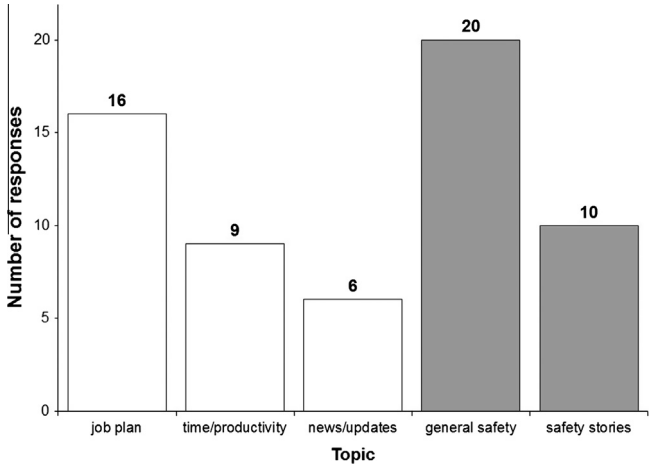

Fig. 1. Topics discussed during pre-shift meetings for those reporting meetings at work ($n = 21$ out of 28 surveyed). Respondents were able to select multiple topics. Safety topics are highlighted in gray.

evidence-based tactics such as using bold font alert words on colored backgrounds, drawings or images to enhance understanding of the hazards, and bullet pointed lists to specify preventive behaviors. Other requirements were that one side of the guide includes the fatal story narrative and prevention recommendations to be read by supervisors, and that the other side included an image of some type with prevention recommendations that could be shown to workers. Students were allowed to be inventive within these parameters. Each team met to review draft guides and provide each other with feedback before turning in their final products. At the end of the course, students produced fourteen draft guides based on eight different fatal incidents.

Following the course, the first author (OR-FACE Program Director) created a standardized template for guides that integrated innovative features generated by students. The best student guides were then revised into the new template format and edited for accuracy. The image side of the template required a simplified black and white line drawing made in PowerPoint, a bold alert word above the drawing on a red background, and bullet pointed recommendations at the bottom. The supervisor side included text describing the incident, bullet pointed recommendations for prevention, and prompts for discussion and active follow-up (see Fig. 2 to view an annotated guide that was tested in field studies).

2.2.1. Study 2: Image viewing distances and preferences

The choice to use simplified black-and-white line drawings in the toolbox talk template was based on evidence that such drawings can enhance understanding of safety messages (Larkin and

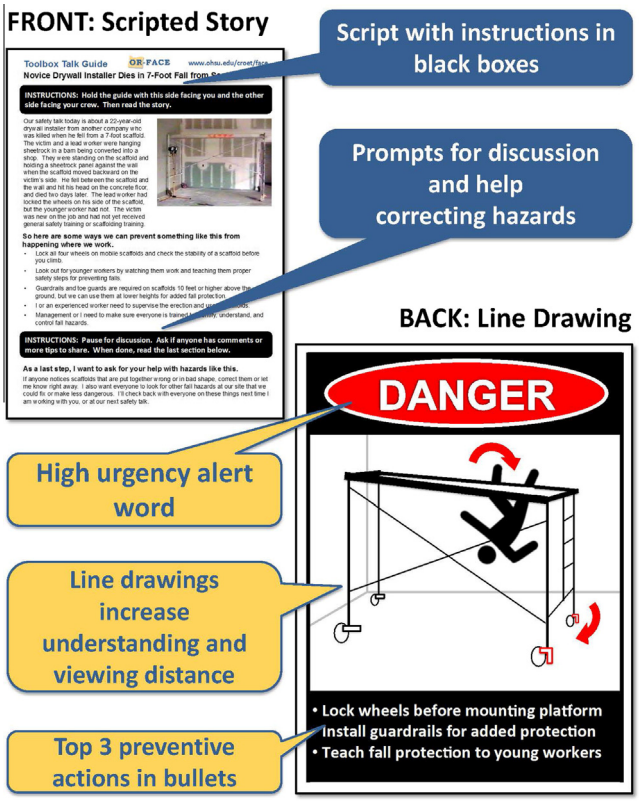

Fig. 2. Annotated front and back sides of an OR-FACE toolbox talk guide format as evaluated in the current study.

Larkin, 2007). We also observed a commercial construction toolbox talk where workers tended to spread out and stand as far as 50 feet away from the foreman or supervisor. To test for the potential advantages of our line drawing format relative to standard photographs, we designed a 2 × 2 factorial study to evaluate workers' viewing distances for correctly identifying content in different types of images. Specifically we tested viewing distances while manipulating: (1) image size (11 × 17 in [28.0 × 43.2 cm] vs. 8.5 × 11 in [21.6 × 28.0 cm]) and (2) image type (photograph vs. line drawing).

2.2.2. Study 2: Participants and setting

Study 2 was conducted at a commercial construction site in the Portland Oregon Metropolitan area. Participants ($n = 30$) were recruited inside a large lunch pavilion during their breaks where they were approached and asked to participate in a short study of safety images. After obtaining verbal consent researchers interviewed workers about demographics and use of corrective glasses or lenses. Participants then tested images according to the methods described below and were compensated with a $5 coffee gift card.

2.2.3. Study 2: Methods and measures

Study 2 employed a factorial design with four conditions. However, we were interested in testing images from five different fatal cases. Therefore, in advance of testing, we created 30 packets of five images each (one for each fatal case). Every packet included all four conditions, with the order of cases and condition varying in quasi-random fashion. The fifth case in each packet repeated one of the four experimental conditions (also quasi-random). The result was that each possible image type and size was presented to seven or eight workers. Each participant started each trial by standing 20 m away (65 ft and 7 13/32 in.) from a tripod with a single image placed on a display shelf. The display shelf was 1.35 m (4 ft 5 in.) off the ground, which is roughly the height an average male supervisor would hold an image while standing. A measuring tape was placed on the ground between the starting line and the tripod. For each image the worker was asked to slowly walk forward and then stop when he/she could correctly identify (a) the equipment in the image (e.g., scaffold), (b) the fatal hazard identified by red arrows in the image (e.g., unlocked scaffold wheels), and (c) correctly read the text on prevention tactics aloud. When a worker gave a correct answer, the researcher recorded the distance. If the worker gave an incorrect answer, they were asked to resume slowly walking forward and then stop again when ready to provide another answer. Thus, outcome measures included viewing distances in meters for correctly identifying/reading equipment, hazards, and text. Workers were also asked to choose the size and type of image they preferred.

2.2.4. Study 2: Independent variables

Machinery, equipment, or settings depicted in the images were related to the following fatal incidents: a fall from a baker's scaffold (OR-FACE investigation report number OR 2006-03-1), a fall from another similar but unspecified type of scaffold (CA-FACE investigation report case number 11CA002), a variable-reach forklift with a load of lumber that shifted and dropped onto a worker on the second story of a residential building (OR-FACE investigation report number OR 2003-16-1), a stack of plywood falling off of a roof onto a worker who was standing on an extension ladder (OR-FACE abstract case number OR 2005-64-1), and a worker falling through an uncovered residential elevator shaft (OR-FACE investigation report number OR 2003-10-1).

Photographs were selected from each original investigation for presentation. Line drawings were simplified versions of photographs, created in PowerPoint, with the primary object drawn to roughly the same size as depicted in photos. In both types of images red arrows pointed to fatal hazards. Line drawings included block figures indicating where the victim was when the incident happened.

Table 2 provides the dimensions of the two image sizes tested which were selected based on what a supervisor could store in a clipboard at job sites (whole, or folded in half).

2.2.5. Study 2: Analyses

R statistical software version 3.0.2 was used for analyses. The mean viewing distances for each criterion (equipment, hazard, and text) and their corresponding standard deviations were computed to describe effects of the two independent variables (image type and image size) on the outcomes (viewing distances for three criteria). Linear mixed effect models were used to test for differences between each condition and for interaction effects. Several potential covariates were tested in models and found non-significant (age, vision impairment, and presence/lack of corrective lenses). Final models included only image size and type as fixed effects and subject as the random effect (b_{0i} is the subject specific random intercept), where Y is equipment distance, hazard distance, or text distance:

$$Y = \beta_0 + \beta_1 size + \beta_2 imagetype + b_{0,i} + \varepsilon, b_{0,i} \sim N\left(0, \sigma^2_{b0i}\right), \varepsilon \sim N(0, \sigma^2)$$

2.2.6. Study 2: Results and discussion

Line images, compared to photos, produced superior viewing distances for both equipment (model estimate 1.47 m) and hazards (model estimate 1.66 m; $p < .00$). Small images required closer viewing distances across all three viewing criteria ($p < .00$). Text viewing distances were not significantly different across image type (line vs. photo; $p = .85$). Interaction terms were

Table 2
Dimensions of elements tested.

	Large	Small
Paper size	11 × 17 in (28.0 × 43.2 cm)	8.5 × 11 in (21.6 × 28.0 cm)
Alert word (DANGER)		
Font	Calibri	Calibri
Height	15/16 in (2.3 cm)	11/16 in (1.7 cm)
Image		
Height	7 1/16 in (17.8 cm)	5 1/4 in (13.3 cm)
Width	9 in (22.9 cm)	6 7/8 in (17.5 cm)
Bullet points (text)		
Font	Calibri	Calibri
Capital letter height	5/16 in (0.7 cm)	1/4 in (0.6 cm)

Table 3
Model estimates of mean viewing distances in meters and corresponding 95% confidence intervals.

Image size and type	Equipment distance [95%CI] SE = 0.37	Hazard distance [95%CI] SE = 0.34	Text distance[a] [95%CI] SE = 0.15
Large line	7.85 [7.12, 8.59]	7.13 [6.47, 7.80]	4.63 [4.33, 4.93]
Large photo	6.38 [5.64, 7.11]	5.47 [4.80, 6.14]	4.62 [4.32, 4.91]
Small line	6.58 [5.85, 7.32]	5.65 [4.98, 6.32]	3.63 [3.33, 3.93]
Small photo	5.11 [4.37, 5.84]	3.99 [3.32, 4.66]	3.62 [3.32, 3.91]

Note: CI = confidence interval.
[a] Effects of image type (line vs. photo) on text viewing distance were not significant for both small and large size images, but model estimates are included in the table for consistency.

non-significant (see Table 3 for model estimates and 95% confidence intervals).

Fig. 3 illustrates patterns in observed effects, where both image size and type affected the equipment and hazard viewing distances, but text viewing distances were only affected by image size.

The results of study 2 supported the use of line drawings as images in toolbox talks. However, while large line images performed best, for study 3 we used the smaller size line drawing format because it would be the most common paper size stocked in printers at construction field offices.

2.3. Study 3: Field evaluation of guides for toolbox talks

Study 3 was an evaluation of supervisor and worker reactions to two different types of toolbox talks at construction sites. Specifically, we compared supervisor and worker reactions to (*A*) talks given using the new one-page guides versus (*B*) talks given using long form fatality investigation reports. Our hypotheses were that relative to condition *B*, condition *A* would result in (1) higher desirability and utility reaction ratings (reaction), (2) higher correct identification of hazards and preventive measures (learning), and (3) stronger intentions to engage in prevention behaviors and share the story with other workers (behavior intentions). We further hypothesized that one-page guides would (4) require less preparation and presentation time than talks based on full investigation reports.

2.3.1. Study 3: Participants and setting

A commercial construction company (different from the company in study 2) was the setting for study 3. The safety director arranged for eight work crews from two construction sites to participate. Trades represented in these crews included roofers, ironworkers, sheet metal workers, plumbers, and carpenters. A supervisor or foremen presented two talks to each crew spaced about two weeks apart while researchers conducted observations and collected reaction surveys. A total of 11 supervisors or foremen participated in toolbox talk presentations and surveys (2 out of the 8 crews had either more than 1 supervisor participate in talks on each occasion, or a different supervisor present the second talk). A total of 99 workers listened to talks and completed surveys during the first trial (crew size $M = 12.38$, SD = 8.72). A total of 107 workers listened to talks and completed surveys in the second trial (crew size $M = 13.25$, SD = 7.61). To maximize the probability of honest ratings with a supervisor present, reaction surveys were anonymous and had no names. Therefore, while most of the workers attended both toolbox talks, scores could not be linked across trials. Research staff provided donuts and coffee before each talk, and $5 gift cards to each participant who completed surveys after the second trial.

2.3.2. Study 3: Methods and measures

Each crew was exposed to conditions (*A*) or (*B*) in random order. On each visit researchers arrived 15–30 min early to explain the process to the supervisors and provide them with the material for the toolbox talk. Supervisors were told that we were evaluating two types of material to help them present fatality stories and provide preventive recommendations in toolbox talks. The format of the material was not described to the supervisors in advance. For condition (*A*) supervisors were told to spend as much time as they needed to prepare but to otherwise follow the instructions on the guide. For condition (*B*), supervisors were told to review the long form information for their crew and summarize it in their talk in a way that made most sense to them. After obtaining verbal consent from the supervisor for their crew to engage in this process, he or she was left alone to review the guide (condition *A*) or full report (condition *B*) and prepare for the talk. Researchers observed and recorded the duration of toolbox talks and total meeting time. Following each toolbox talk workers and supervisors were given short reaction surveys. After the second and final talk, workers and supervisors completed an exit survey with additional evaluation and demographic questions.

Reaction surveys addressed favorability and utility ratings, learning, and behavioral intentions (Alliger et al., 1997). In the workers' reaction surveys, the first three reaction questions were rated on a scale of 1–5 (1 = strongly disagree, 5 = strongly agree) and included "I liked how this fatality story was shared or presented", "The information shared will be useful to me in my work", and "The time it took up out of our work day to share this topic was just right." Open-ended learning questions were "What were the hazard(s) in this fatal story?" and "What were the recommendations for eliminating or reducing the hazard(s)?" Behavioral intention questions were rated on a scale of 1–5 (1 = strongly disagree, 5 = strongly agree) and included "In the future, I will do something new or different at work based on hearing this story," "In the future, I will do something better or more consistently at work based on hearing this story," and "I will tell this story to other workers I meet who haven't heard it before." The reaction survey also included a single item that asked, "How urgent or important is it for workers to hear about the hazard(s) in the story?" (1 = not urgent at all, 5 = extremely urgent), as well as two open-ended questions soliciting feedback about favorite aspects about the story and ways to improve or make the story better. The supervisor reaction survey included one extra question asking them how much time it took them to prepare to give the toolbox talk. All other questions were the same except for slightly modified versions of the first three reaction questions. These were "How easy or hard was it to present this fatality story?" (1 = very easy, 5 = very hard), "The information shared will be useful to me and my employees in our work" (1 = strongly disagree, 5 = strongly agree), and "The time it took up out of our work day to share this topic was just right" (1 = strongly disagree, 5 = strongly agree).

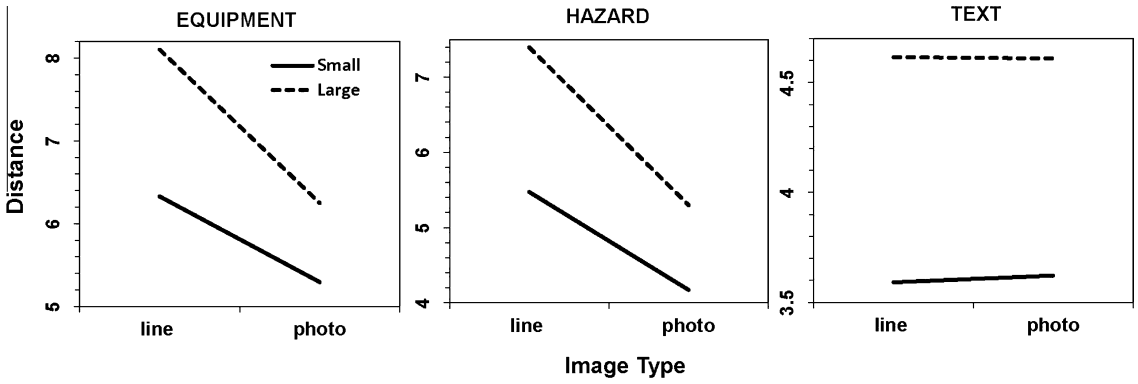

Fig. 3. Interaction plots of viewing distance means for each criterion across experimental conditions.

The exit survey, which was administered after the second trial reaction surveys were collected, asked supervisors and workers for their preferences for which talk they preferred (the talk where a line drawing was included, or the one without the line drawing), and which story was most memorable. The post study survey also included demographic items and questions about the frequency of pre-shift meetings under typical work conditions at their company (similar to study 1 survey), as well as opportunities to provide researchers with further feedback.

2.3.3. Study 3: Independent variables

Four of the five cases from study 2 were used in study 3, with the fall from a scaffold (CA-FACE investigation report case number 11CA002) being excluded due to redundancy with a similar Oregon case. Researchers called each supervisor in advance of the first visit to discuss available cases and select the two that were most relevant for each crew (e.g., some crews or trades didn't use scaffolds). None of the supervisors selected the case involving a fall down a residential elevator shaft (OR-FACE investigation report number OR 2003-10-1). As noted, the order of conditions for each crew was randomly assigned (*A* or *B*). Then, in a quasi-random fashion, the specific cases selected by supervisors were assigned for presentation in each condition in a fashion that maximized balance in both the order of the format presented (random) and the specific cases presented (quasi-random) to the degree possible.

2.3.4. Study 3: Analyses

Descriptive statistics were computed for sample characteristics, workplace practices, and reaction survey responses. Reaction responses, such as strongly agree or agree (4 or 5) and strongly disagree or disagree (1 and 2), were categorized in the summary. A review of responses to learning questions revealed prevalent missing data and non-specific answers, and thus were not analyzed. To test for differences across formats, generalized estimating equations for ordinal responses were used to evaluate repeated measures of reactions and behavioral intentions with work site as the clustering variable. A mixed effects regression model was constructed to test for differences in presenters' self-reported time it took to prepare for the talks. Paired *t*-tests were performed to test for differences in the length of time it took to tell the fatality story and if the total meeting times differed across the two formats. Intercept only logistic regression models were constructed to test for differences in supervisor and worker preferences for talk format.

2.3.5. Study 3: Results and discussion

Exit survey responses after trial 2 provide a general demographic description of the sample and reports of normal toolbox talk practices. However, it is not a perfect sample description. For example, one presenting supervisor at trial 1 was female, but all supervisors who participated in trial 2 and completed demographic surveys were males ($n = 11$) with an average age of 45.73 years (SD = 7.28). At trial 2 workers ($n = 107$) averaged 41.14 years of age (SD = 11.09) and were predominantly male (97 male, 5 female; and 5 not reporting sex). Of the 11 supervisors, seven reported that they conducted pre-shift meetings at least once per week and discussed safety at least once per week. Of 107 workers, 85 reported that pre-shift meetings were conducted at their worksite. Of those 85 workers, 81 reported that the meetings were conducted at least once per week and 78 reported that safety was discussed at least once per week. Only a few workers expressed interest in foreign language translations of talks (Spanish = 4; French = 1; Hungarian = 1).

Generalized estimating equations revealed no significant differences in reaction outcomes across the two toolbox talk formats. Reactions across both conditions were favorable, including over 88% worker agreement and 100% supervisor agreement that the topics were urgent or important to discuss. Over 60% of workers and supervisors in both conditions agreed that they would do something better as a result of having heard the fatal stories. See Table 4 for a summary of workers reactions and behavioral intentions. See Table 5 for a summary of supervisors' responses.

Supervisor preparation times for formats (*A*) and (*B*) averaged 5.18 (SD = 3.63) and 12.45 (SD = 7.94) minutes, respectively. The mixed effects regression model showed that an estimated savings in preparation time of 7.27 (SD = 2.58) minutes was statistically significant ($p = .015$). Supervisor presentation time for format (*A*) averaged 3.63 min (SD = 1.51), with an average total meeting time of 15.75 min (SD = 7.83). Presentation time for format (*B*) averaged 9.50 min (SD = 4.50), with an average total meeting time of 16.38 min (SD = 4.78). Paired *t*-test results indicated that the difference in presentation time of 5.88 min was statistically significant ($p = .017$). However, there was no evidence of difference in the total meeting times across the two presentation styles ($p = .874$), suggesting that presentation time saved was dedicated to additional discussion among crews (see Fig. 4 for means and 95% confidence intervals for preparation, presentation, and total meeting times). Anecdotally, researchers noted that workers were active participants in these discussion periods.

Nine out of eleven supervisors (81.82%) preferred the one-page guides to full-length investigation reports. An intercept only logistic regression model was fit with supervisor preference as the response, and this level of preference was statistically significant (odds 4.50, SD = 2.19, $p = 0.054$). Seven of eleven supervisors surveyed agreed or strongly agreed that they would use one-page guides in future toolbox talks if provided, and four supervisors indicated this same level of agreement for future use of full fatality investigation reports. Of the 107 worker surveyed, 71 preferred

Table 4
Percent of workers selecting reaction question answers across presentation conditions.

Questions	(*A*) talks using one-page guides (n = 101)				(*B*) talks using long-form reports (n = 104)			
	Strongly agree/ agree (%)	Neutral (%)	Strongly disagree/ disagree (%)	No response (%)	Strongly agree/ agree (%)	Neutral (%)	Strongly disagree/ disagree (%)	No response (%)
Reaction								
Liked	72.28	23.76	2.97	0.99	65.38	29.81	4.81	0.00
Useful	77.23	19.80	2.97	0.00	76.92	15.38	6.73	0.96
Duration	68.32	28.71	2.97	0.00	68.27	24.04	6.73	0.96
Urgent	88.12	9.90	0.99	0.99	88.46	10.58	0.96	0.00
Behavior								
Do something different	53.47	37.62	5.94	2.97	60.57	27.88	9.62	1.92
Do something better	66.34	27.72	4.95	0.99	70.19	24.04	4.81	0.96
Retell story	52.48	36.63	9.90	0.99	48.08	36.54	14.42	0.96

Note. Both sample sizes approximated 100 so percent responding was selected as best summary statistic. No differences between formats were statistically significant.

Table 5
Percent of supervisors/presenters selecting reaction question answers across presentation conditions.

Questions	(*A*) talks using one-page guides (n = 11)				(*B*) talks using long-form reports (n = 11)			
	Strongly agree/ agree (%)	Neutral (%)	Strongly disagree/ disagree (%)	No response (%)	Strongly agree/ agree (%)	Neutral (%)	Strongly disagree/ disagree (%)	No response (%)
Reaction								
Liked	NA	NA	NA	NA	NA	NA	NA	NA
Useful	90.91	9.09	0.00	0.00	100	0.00	0.00	0.00
Duration	100	0.00	0.00	0.00	81.82	9.09	0.00	9.09
Urgent	100	0.00	0.00	0.00	100	0.00	0.00	0.00
Behavior								
Do something different	36.36	54.55	0.00	9.09	45.45	45.45	0.00	9.09
Do something better	63.64	27.27	0.00	9.09	63.64	18.18	9.09	9.09
Retell story	54.56	27.27	0.00	18.18	72.73	9.09	9.09	9.09

Note: Supervisor sample size approximated 10, so percent responding was selected as best summary statistic. No differences between formats were statistically significant. NA = not applicable, as supervisors were not asked to rate whether they liked the material.

talks using one-page guides, 23 preferred talks with full investigation reports, and 6 reported no preference. Worker preference for the one-page guides was also significant in a logistic regression analysis (odds 3.09, SD = 1.27, $p < 0.001$).

2.4. Final adaptation and publication

Following the completion of study 3, the toolbox talk guides received minor edits and were then sent out for review by the OR-FACE publications review panel comprised of safety and construction experts. This round of feedback resulted in a change to fully scripted (rather than partially scripted) supervisor text for telling the story, sharing recommendations, and planning follow-up with crews. The fully scripted and finalized toolbox talks were then published for use by the public. Website analytics indicate that the toolbox talks have become one of the most frequently downloaded OR-FACE products. Given the popularity of the construction toolbox talk initiative, the effort has since been extended to the forestry and logging industry.

3. Discussion

The current project represents a rare empirical investigation of safety toolbox talks in the construction industry and provides evidence for the benefits of brief toolbox materials for supervisors. Formative needs assessment research identified opportunities for improving the frequency and safety content of toolbox talks in construction firms. For example, 25.0% of those surveyed never conducted pre-shift meetings of any kind. However, participants also indicated a willingness to share fatality stories and prevention recommendations if provided with one-page toolbox talk guides. In collaboration with an Occupational Health Psychology program and commercial construction company, we developed a one-page (double-sided) structure for toolbox talks about fatalities based on evidence-based principles. In study 2 we confirmed empirically that simple line drawings, relative to photos, increased workers' correct identification of equipment and hazards by 1.47 m and 1.66 m, respectively (model estimated means). In a repeated measures experiment with eight construction crews we found that brief toolbox talk guides were preferred by 81.82% of supervisors and saved them approximately 15 min of preparation/presentation time. These findings are important because time and profit pressures are common safety obstacles reported by construction managers (Gillen et al., 2003). Time saved was dedicated to extra discussion among crews, which is a desired outcome in safety talks according to safety professionals (Forck, 2005; Williamsen, 2003). Moreover, the brief toolbox talk format had equally favorable impacts on worker behavioral intentions relative to talks given based on longer-form materials. In sum, relative to longer form technical documents, brief scripted toolbox talks with line drawings were preferred by supervisors, saved time that was dedicated to discussion, and generated equal impacts on crew members' behavioral intentions.

In study 3, we tested several a priori hypotheses and should consider relative support for each one. Our first hypothesis was that relative to talks given based on long-form fatality investigation reports, that our new brief toolbox talks would result in higher

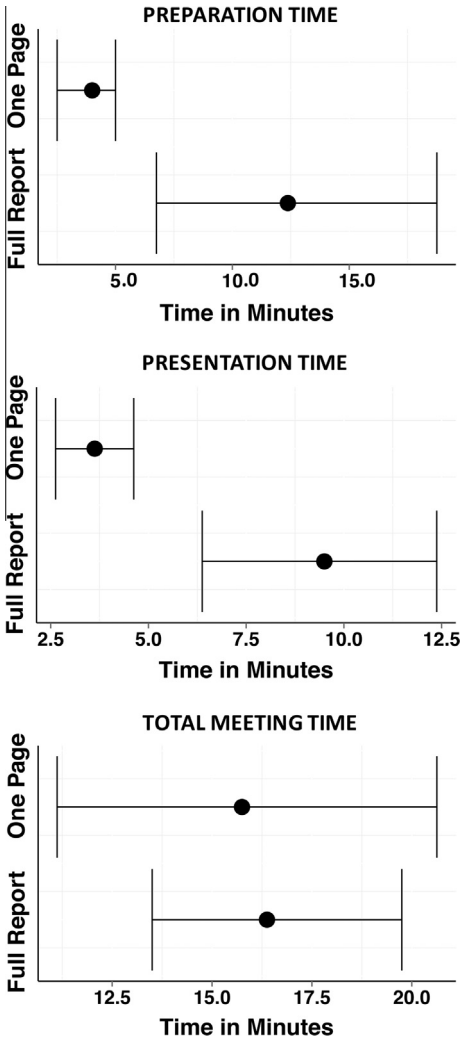

Fig. 4. Preparation, presentation, and total meeting durations for supervisors/presenters across conditions: means and 95% confidence intervals.

desirability and utility reaction ratings (reaction). This hypothesis was partially supported by our findings. Both toolbox talk formats resulted in similar (non-significant) immediate reaction ratings by workers. However, in exit surveys the brief toolbox talks had significantly higher odds of being preferred by supervisors (increased odds = 4.50) and workers (increased odds = 3.09). Our second hypothesis was that toolbox talks based on brief guides would result in better ability to correctly recall hazards and prevention recommendations from the incident (learning). This hypothesis was not tested due to missing and problematic data on these questions in the survey. Our third hypothesis was that talks based on guides would result in stronger intentions to engage in prevention behaviors (behavior intentions). This hypothesis was not supported. As with immediate reaction ratings, both toolbox talk formats resulting in similar (non-significant) immediate ratings of behavioral intentions. And finally, we hypothesized that one-page guides would require less preparation and presentation time than talks based on full investigation reports. This hypothesis was supported with significant differences between conditions in preparation and presentation time (approximately 15 min saved in total).

The current project possesses several strengths. These include early guidance and input from industry stakeholders in study 1, engagement with a construction company and an occupational health psychology training program in developing an evidence-based structure for the toolbox talks, conducting a field experiment with workers at that company to test the benefits of the illustration format selected for the guides, and evaluation of the guides with a repeated measures design at eight construction sites at a second company. This design used each crew as its own control and the order of condition exposure was randomized, thereby minimizing order effects as a confounding factor.

Limitations suggest areas for future research. All studies involved convenience samples that may not be representative of the construction industry at large or of workforces at our corporate partners. While we attempted to recruit residential construction firms into the study, these efforts did not succeed, and we ultimately turned to commercial construction partners. This is a limitation because construction fatalities in Oregon are more common in residential construction. In fact, all of the fatal incidents in the toolbox talks studied occurred at residential construction sites. It is critically important that researchers continue to experiment with ways to better engage with residential construction partners. The current project also lacked an experimental comparison of talks with and without real case studies. While there is evidence that workers perceive true stories as important and compelling, we are not aware of an experiment that has explicitly tested this assumption. And finally, experimental conditions in both studies 2 and 3 had elements that were not perfectly balanced, and some aspects were quasi-randomized instead of fully randomized. Design sacrifices were made to accommodate practical realities, such as permitting supervisors to choose cases for presentation in order to ensure relevance of toolbox topics for crews. Future researchers should continue striving to maximize design quality while simultaneously balancing practical constraints of construction worksites and practices.

4. Conclusions

The ultimate purpose of fatality surveillance research and outreach is to reduce workplace deaths in high-risk industries. Construction workers are exposed to frequent and dynamic occupational hazards, and subsequently experience fatality rates nearly three times the US average. While the first priority in occupational safety is to remove hazards from the workplace altogether, some hazards may not be completely removed and must be controlled through administrative processes like safety training and meetings. Frequent safety-related communication is associated with higher levels of safe behavior and conditions and higher perceived safety climate. In construction, safety toolbox talks are perceived as an important form of safety communication and provide opportunities for supervisors to communicate safety priorities. One method to increase the frequency of safety toolbox talks about fatality prevention practices in construction is to develop easy to use materials for supervisors. The current project was designed to develop and evaluate an evidence-based toolbox format for this purpose. Our research provides further support for prior findings that simple line drawings can enhance safety communication (increased workers' ability to see and correctly identify equipment and hazards in fatal incidents). But perhaps most importantly, we found that brief one-page toolbox talk guides saved time and were strongly preferred by supervisors. This should encourage the development of simple, easy to use materials to get fatality prevention information delivered directly to line workers on the job.

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