



# Efficacy of text messaging apprentices to reinforce ergonomics and safety voice training

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## ABSTRACT

**Introduction:** Injuries and work-related musculoskeletal disorders (MSDs) are common among masons. **SA**afety **V**oice for **E**rgonomics (SAVE) integrates training in ergonomic and safety problem-solving skills into masonry apprenticeship training. The purpose of this study was to assess the efficacy of text messaging to reinforce SAVE program content. **Method:** SAVE effectiveness was evaluated at masonry apprenticeship training centers across the United States by comparing three experimental groups: (1) Ergonomics training, (2) Ergonomics and Safety Voice training, and a (3) Control. Apprentices received SAVE training with their standard instruction. To reinforce classroom training, refresher training was implemented by sending weekly text messages for six months. Half of the text messages required a response, which tested knowledge or assessed behavior, while the remaining reiterated knowledge. Apprentices ( $n = 119$ ) received SAVE text messages. Response rates and percentage of correct responses were compared with chi-square tests and independent group  $t$ -tests. Multivariable logistic regression analysis predicted apprentice response with selected demographic and work experience variables. Finally, feedback on the use of text messaging was obtained. **Result:** Of 119 participants, 61% ( $n = 72$ ) responded to at least one text message. Logistic regression revealed that being a high school graduate and a brick and block mason significantly affected the odds of responding. Sixty-nine percent of apprentices agreed that text messages reinforced SAVE content. **Conclusion:** Even though there was no training center requirement to respond, the high response rate suggests that text messaging can effectively be used to reinforce ergonomics and safety voice training for both knowledge and behavior. **Practical Application:** The prevalent use of text messaging creates opportunities to reinforce health and safety training and engage workers, especially for populations that may be at various locations over time such as construction sites. Instructors and practitioners should consider the utility of text messaging for supporting their training and safety programs.

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## 1. Introduction

Traumatic injuries and work-related musculoskeletal disorders (MSDs) continue to be a problem in the construction industry. The industry currently ranks third behind transportation and agriculture for the rates of both fatal and nonfatal injuries (CPWR, 2013, charts 38c and 38e). More specifically, the masonry trade continues to rank high for overexertion and back injuries among all construction trades (CPWR, 2013, charts 48e and 49d). Apprentices are an important population to target with safety and

ergonomics training in order to promote safe work habits early in their trade. It is common for apprentices to be coming into the trades from other work, so they tend to be in their later twenties. Nonfatal injury data in the construction industry show that the distribution of nonfatal injuries were historically highest in the 25–34 age group, but in the most recent data from 2015, plateau at the highest percentages in the age groups from age 25 through 55 years (CPWR, 2013, chart 41b).

Ergonomic solutions are the primary method of reducing exposure to risk factors associated with MSDs. However, many construction workers, beginning with trade apprentices, lack knowledge about ergonomic principles, solutions, and associated risk factors for MSDs. In addition, apprentices may not have experience or training on appropriately identifying and responding to

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unsafe work environments and practices. The ability of a worker to speak out in an attempt to improve unsafe environments and practices can be considered a “safety voice” (Tucker, Turner, Hershcovis, Chmiel, & Stride, 2008). Soft skills associated with safety voice include problem solving strategies, communication methods, and conflict resolution approaches. Training early in a worker’s career, to reduce cumulative trauma leading to injuries, is an important means for changing safety climate on construction sites.

**Safety Voice for Ergonomics (SAVE)** is an occupational safety program that integrates ergonomic and safety voice principles into masonry apprenticeship training. SAVE was developed and tested in a clinical trial (NCT02676635) with masonry apprentices nationally between 2014 and 2018. It was then made widely available to apprenticeship training programs in 2019 (CPWR, 2019). When developing SAVE, the research team drew on their experience developing ergonomics training for the construction trades and integrated interactive learning techniques that appeal to younger workers. During development, stakeholders in the masonry trade provided insight into masonry workplace hazards and feedback about the training. SAVE was integrated into traditional apprenticeship classroom training by including 3–4 h of ergonomics and safety voice content or primary training. In order to reinforce knowledge and skills gained from primary training, text messaging was used as a secondary training method in the six-month period following the classroom training. Text messaging leveraged the near ubiquitous use of smartphones as a communication tool, especially among younger workers, and reached apprentices who were employed on different construction sites as part of their apprenticeship. Text messages either required a response to a question about ergonomics or safety voice knowledge, or simply supplied apprentices with a reminder about an ergonomics or safety voice concept from the classroom training.

Few occupational health and safety studies have used text messaging to influence safe behavior (Duffy, Ronis, Waltje, & Choi, 2013). Further, there is a dearth of studies using text messaging for assessing occupational health and safety knowledge including ergonomics knowledge (de Lepper et al., 2013; Froisland, Arsand, & Skarderud, 2012). It is unknown whether apprentices would be responsive to text reminders aimed at reinforcing occupational health and safety knowledge. Therefore, the purpose of this study was to evaluate of the efficacy of text messaging for assessing knowledge retention and influencing behavioral change following SAVE training. A secondary purpose was to assess the utility of text messaging for communicating with study participants about study logistics, such as reminders to complete study-related outcomes assessments in the follow-up period.

## 2. Materials and methods

### 2.1. SAVE description

The SAVE classroom training consisted of seven units developed by the researchers with four units dedicated to ergonomics and three to safety voice content during the study evaluation (Table 1). Each unit, taught by apprenticeship instructors at the various sites, included a 10–17-minute video. To teach SAVE, local apprenticeship instructors played the unit video and paused at indicated times for discussions, quizzes, and activities. SAVE materials included an apprentice workbook and a detailed instructor manual that followed the video content (CPWR, 2019). Instructors taught SAVE after reviewing SAVE materials and participating in train-the-trainer instruction from a research team member.

For refresher training, SAVE text messages were sent at regular intervals for six months after the classroom training in order to

reinforce content. Forty unique texts covering the ergonomics content and 28 covering the safety voice content were used (see Supplementary Tables S1 and S2). The differing number of texts for the ergonomics and safety voice was due to the difference in content for each: there were four ergonomic units and therefore more texts related to ergonomics concepts, while there were three safety voice units and fewer texts. Half of the text messages required a response from the apprentice, which either tested knowledge or assessed behavior, while the remainder did not require a response and simply reinforced SAVE key points. Therefore, only the half of the texts that required a response could be analyzed (see Section 2.3). An ergonomics *knowledge* text example was, “Does the A in HARP stand for Awkward Postures?” The apprentice could respond to the text either “Yes” or “No,” with the correct answer being “Yes” as learned in SAVE. A reinforcement text was sent depending on the response to clarify the correct answer. An example of an ergonomics behavioral assessment was, “Have you used any Work Practice Solutions this week such as using adjustable scaffolding or using good body postures?” The apprentice could respond either “Yes” or “No” then received a follow-up reinforcement text message. An example of an ergonomics *key point reinforcement* text was, “Regularly ‘shift to neutral’ posture to minimize your risk of being injured,” intended to remind apprentices to limit awkward, potentially harmful low back postures. Shifting to neutral reminded apprentices to keep work in the safe zone between their shoulders and knees. A safety voice *knowledge assessment* text message example was, “Over half of all communication is non-verbal. Is your facial expression an example of non-verbal communication?” Again, the apprentice could respond either “Yes” or “No” and then receive a follow-up reinforcement text message. There were no text messages for safety voice behavioral assessments, as the study team determined such soft skills were harder to report and that each apprentice could have a wide range of work experiences during the study period.

### 2.2. SAVE evaluation study design

Study participants were 119 apprentices from eight masonry apprenticeship training centers geographically distributed across eight states who had completed primary in-class SAVE training covering ergonomics ( $n = 54$ ) or ergonomics and safety voice usage ( $n = 65$ ). Participants provided written consent to participate in the SAVE program and to receive the reinforcement text messages. All associated service costs for text messaging were the participants’ responsibility. Participants were eligible for inclusion if they were currently enrolled in apprenticeship training, 18 years of age or older, and English-speaking. Apprentices were ineligible for participation if they did not own a cell phone with capability to receive text messages. The SAVE Program was approved by the Institutional Review Boards of Eastern Washington University, University of Oregon, and Oregon State University.

The SAVE Program was evaluated in a clinical trial with a three group, cluster randomized-controlled study design (Kincl, Anton, Hess, & Weeks, 2016). Clusters of apprentices within centers were randomly assigned to one of three groups with two receiving the SAVE training intervention: (1) Ergonomics training alone, (2) Ergonomics *plus* Safety Voice training, or (3) Control. The control group received no additional training apart from their usual apprenticeship training, and thus received no text messages reinforcing SAVE content. The control group was not included in the text message-response results. Participants completed surveys that were part of SAVE evaluation (published elsewhere) before the training, two weeks following the training, at 3-months and at 6-months following training. Each participant was compensated \$50 each time a survey was returned for a possible total of \$200.

**Table 1**

The titles and learning objectives of the seven SAVE units evaluated.

SAVE Unit	Title	Learning Objectives
Ergonomics	Unit 1: Anatomy & Cumulative Trauma	<ol style="list-style-type: none"> <li>1. Define ergonomics and know why it is important.</li> <li>2. Understand risk factors for cumulative trauma.</li> <li>3. Identify the causes of work-related musculoskeletal injuries.</li> <li>4. Know how ergonomic practices can be used to reduce injuries.</li> </ol>
	Unit 2: Awkward & Neutral Postures	<ol style="list-style-type: none"> <li>1. List the four ergonomics risk factors. Have a more in-depth understanding of the risk factors for cumulative trauma.</li> <li>2. Describe or demonstrate at least one awkward posture used at work related to the back, shoulders and wrists.</li> <li>3. Describe or demonstrate neutral posture solutions for awkward back, shoulder and wrist postures.</li> <li>4. Understand of why it is important to avoid awkward postures whenever possible, and the importance of using neutral posture.</li> </ol>
	Unit 3: Heavy Lifting, Prolonged Posture & Repetition	<ol style="list-style-type: none"> <li>1. List the four ergonomics risk factors.</li> <li>2. Describe repetitive activities and prolonged postures.</li> <li>3. Understand the risks associated with heavy lifting, prolonged postures and repetition over the course of their career.</li> <li>4. Explain strategies for reducing the risk of heavy lifting, repetition and prolonged postures.</li> </ol>
	Unit 4: Solutions: Equipment, Administrative Controls & Work Practices	<ol style="list-style-type: none"> <li>1. List three categories of ergonomic solutions for masonry.</li> <li>2. Describe several engineering solutions.</li> <li>3. Describe several administrative solutions.</li> <li>4. Describe several work practice solutions.</li> <li>5. Understand the solutions that are directly under their control and the ones that are not, but are important to know and advocate for.</li> </ol>
Safety Voice	Unit 1: Safety Responsibility & Communication	<ol style="list-style-type: none"> <li>1. Define safety voice and know when to use it.</li> <li>2. Understand the rights and responsibilities of employers and masons.</li> <li>3. Identify the hierarchy and chain of command for your local.</li> <li>4. Identify appropriate verbal and non-verbal communication strategies.</li> </ol>
	Unit 2: Identifying Safety Hazards & Information	<ol style="list-style-type: none"> <li>1. Understand the concept of PASS - Problem, Advice, Safety, Solution.</li> <li>2. Analyze a potential hazard to identify root causes.</li> <li>3. Know who to go to for safety advice.</li> <li>4. Know where to look up relevant safety information.</li> </ol>
	Unit 3: Solving Safety Problems with Solutions	<ol style="list-style-type: none"> <li>1. Develop a plan for selecting safety solutions.</li> <li>2. Understand the factors to consider when choosing a solution.</li> <li>3. Understand that conflict is normal and can be positive.</li> <li>4. Use the ABC model to resolve conflicts.</li> </ol>

Two weeks following the SAVE training, the intervention groups began receiving text messages for 6-months, following the schedule described in [Table 2](#).

The messaging schedule started with more frequent texts in the first month, then tapered off gradually over the subsequent months in order to convey the reinforcement without overwhelming the apprentices ([Abroms, Whittaker, Free, Van Alstyne, & Schindler-Ruwisch, 2015](#)). The messages were sent in the order they are shown in the [Supplemental Tables](#), which are organized by the unit they were associated with and alternate between a text that requires a response then not. Texts were sent at 10 a.m. local time and only on weekdays (Monday through Friday). A text messaging system, Slicktext ([www.slicktext.com](http://www.slicktext.com)), was used by the study team to send the scheduled messages and to track responses.

In accordance with our secondary purpose, the text messaging system was also used to communicate study logistics to participat-

ing apprentices. The logistic texts were sent to all apprentices regardless of the group and included controls. Examples of *logistic* texts included a welcome text, reminders for apprentices to respond to study outcome questionnaires mailed to them, and notifications from apprentices to the study team of address changes or situation changes and all are shown in the [Supplemental Material \(Tables S3\)](#). To facilitate return of study outcome questionnaires, up to three reminder texts were sent every few days and were only sent if the questionnaires were not returned. If there was still no response after the three reminder texts were sent, the instructor at the apprenticeship training center was asked to remind the apprentice.

At the conclusion of the 6-month period during which participants received text messages, participants responded to a question asking, "Did the text messages help reinforce the SAVE program?" Participants responded to the question on a Likert scale ranging

**Table 2**

SAVE text messaging schedule for each intervention group.

Group	Ergonomics				Ergonomics + Safety Voice			
	1	2	3	4–6	1	2	3	4–6
Month								
Day of week that one text sent*	M W F	M W	M W	M	M T W Th F	M T W Th	M W	every other M W
# texts sent/week	3	2	2	1	5	4	2	1–2
# texts/month	12	8	8	12	20	16	8	24
Total # texts	40				68			

\*M = Monday, T = Tuesday, W = Wednesday, Th = Thursday, F = Friday.

from 1 = strongly agree to 5 = strongly disagree. Written comments about the SAVE program were also solicited from participants at this time.

### 2.3. Data analyses

The analysis and evaluation of the overall SAVE Program will be reported elsewhere. For evaluating the effectiveness of text messaging for refresher training, statistical analyses were performed for the text messages that required a response with SPSS version 23.0 (SPSS, Chicago, IL). All analyses employed a type I error rate of  $P < .05$ . Demographics of the entire sample were characterized with summary statistics. As well, the demographics of each group were compared with chi-square tests for nominal data and an independent group  $t$ -test for mean age. The percentage of apprentices responding to text messages in the entire group and within each group was calculated. Response rates in each group were compared with chi-square tests and independent group  $t$ -tests. Since only the ergonomics texts were common to both groups (Ergonomics and Ergonomics + Safety Voice), the percentage of correct responses to ergonomics knowledge questions in each group were compared with independent group  $t$ -tests. A comparison of the correct responses to the safety voice knowledge could not be completed since only one group received these text messages.

Multivariable logistic regression analysis was employed to predict the probability that an apprentice would respond to text messages from the demographic and work experience variables of age, sex, race/ethnicity, apprenticeship year, previous education, masonry setting, masonry work performed most often, and potential interaction terms for each demographic or work experience variable on which study groups differed. Logistic regression models were constructed with forward stepwise maximum likelihood procedures. Odds ratios (OR) and corresponding 95% confidence intervals (CI) were assessed for significance of predictive ability of candidate variables and interaction terms.

Frequency counts were calculated from participant responses to the text message feedback question asked at six-months. Comments provided by apprentices at six-months about text messaging were assessed as qualitative feedback. Finally, to assess our secondary purpose, an analysis of the frequency of logistic text messages soliciting the return of study outcomes assessments was conducted with all participants including the control group.

### 3. Theory

Our research team was concerned with the sustainability and application of the knowledge and skills gained from SAVE. It has been well-established that retention of skills and knowledge decays if not used (Arthur, Bennett, Stanush, & McNelly, 1998; Lawani, Hare, & Cameron, 2018). Methods to reinforce and encourage use of new information are important. Refresher training (aka, secondary or booster training) is one method employed in educational psychology research to counter decay. Various types of refresher training have been used successfully in occupational health to enhance retention of knowledge gained during training (Buller, Andersen, & Walkosz, 2005; Hong, Chin, Fiola, & Kazanis, 2013; Lusk, Eakin, Kazanis, & McCullagh, 2004). For more traditional jobs where workers report to a specific job location, they have access to other forms of media, such as posters in break rooms or by time clocks. However, since this was a national study that included apprentices across the United States working on different job sites that might change weekly, the use of text messaging made it possible to reach all apprentices at work regardless of their work location.

In order to enhance the learning process, when designing SAVE we considered elements of two learning theories, Transformative Learning Theory and the Health Behavior Model (HBM). Transformation theory assumes that apprentices will learn by having their beliefs challenged through self-reflection and critical thinking (Mezirow, 1991). Even though apprentices are new to the trade and being taught masonry skills as part of their four-year apprenticeship, they concurrently work on job sites performing masonry duties, creating an opportunity for them to immediately apply new knowledge and skills. The content, activities, and discussions in the SAVE program go beyond providing rote learning, exposing apprentices to critical thinking and encouraging self-examination of accepted behaviors and actions. It encourages them to question assumptions such as the widely held belief that “if I just stay fit I won’t get hurt at work” or “we’ve always done it this way.” Therefore, the active learning elements of SAVE encouraged critical thinking about safety and ergonomics, while weekly text messages reminded apprentices to evaluate their current work situation and apply their new knowledge by speaking up about these issues when seen on the job.

Similarly, HBM provides an excellent rationale for employing text messages to reinforce knowledge and to change behaviors. HBM postulates that risk-avoidance behavior, such as behaviors to avoid acute and cumulative trauma, is influenced by a worker’s perception of the seriousness, susceptibility, benefits and barriers to changing that behavior, self-efficacy, and cues to action (NIH, 2005). The SAVE text messages served as a ‘cue to action’ to promote awareness and increase compliance by actively applying risk-avoidance behaviors on jobsites. Indeed, text messages are being used increasingly to deliver targeted interventions that promote healthy behavior (Carpenter, 2010; Rosenstock, 1974). For example, the HBM was used to guide a text messaging intervention for operating engineers (another construction trade group) with text messages that promoted sunscreen use in these outdoor workers (Jones et al., 2015). Further, a meta-analysis found that text messaging had a positive effect on a broad range of health behaviors (Orr & King, 2015).

## 4. Results

### 4.1. Demographic characteristics

Table 3 displays the demographic characteristics and masonry experience/education for the study sample. A majority were male, white or Caucasian, and had at least a high school education. Most performed brick and block masonry in a commercial setting, and were in apprenticeship year one of four or five years. The single variable on which groups differed significantly was type of masonry work performed most often; a significantly larger proportion of apprentices in the Ergonomics group performed brick and block work ( $P = .019$ ). However, 80–95% of the apprentices in all the groups performed brick and block work, which was expected since this was our target craft among several masonry crafts.

### 4.2. Response rates to text messaging and predictors of responding

Of the 119 participants who completed the SAVE training, 61% ( $n = 72$ ) responded to at least one text message. Within the Ergonomics group, 70% responded to at least one text message. The response rate of 52% in the Ergonomics + Safety Voice group was significantly different ( $P = .045$ ). Of the texts that required a response (20 texts in the Ergonomics group and 34 texts in the Ergonomics + Safety Voice group), the percent response was 55% in the Ergonomics and 57% in the Ergonomics + Safety Voice group. This difference among groups was not significant ( $P = .742$ ).

**Table 3**

Demographic characteristics for the entire group and per group. Asterisk denotes variable in which percentages differed significantly between groups ( $P < .05$ ). Percentages within a variable may not sum to 100% due to rounding.

		Intervention Group		
		Ergonomics Only ( $n = 54$ )	Ergonomics + Safety Voice ( $n = 65$ )	All ( $n = 119$ )
Sex	Male	100.0%	94%	97%
	Female	0%	6%	3%
Race/Ethnicity	African American/Black	13%	26%	20%
	American Indian/Alaska Native	2%	0%	1%
	Asian	0%	0%	0%
	Latino or Hispanic	15%	17%	16%
	White or Caucasian	70%	52%	60%
	Other or Multi-racial	0%	6%	3%
Education Completed	Some High School or Less	4%	5%	4%
	High School Graduate	46%	50%	48%
	Trade/Technical School Training	18%	24%	21%
	Some College/Associates Degree	25%	16%	20%
Masonry Work Performed Most Often*	College Graduate	9%	5%	7%
	Brick and Block	95%	80%	87%
Setting Where Masonry Mainly Performed	Other	5%	20%	13%
	Residential	4%	3%	4%
Apprenticeship Year	Commercial	84%	92%	88%
	Industrial	13%	5%	9%
	1	58%	48%	52%
Mean Age (Std. Dev.)	2	35%	29%	32%
	3	8%	10%	9%
	4	0%	14%	8%
		27.6 (6.9)	29.7 (8.2)	28.8 (7.7)

A multivariable logistic regression model that included age, race/ethnicity, previous education, and masonry work performed most often revealed a few predictors that significantly increased the odds of responding to text messages: Holding other variables constant, the odds of responding to text messages were 11-times higher for apprentices graduating from high school than for apprentices with a college education (OR = 11.34; 95% CI = 1.46–88.05,  $P = .029$ ), and 22-times higher for apprentices with an associate degree or some college than for apprentices with a college education (OR = 22.82; 95% CI = 2.24–232.75,  $P = .008$ ). The odds of responding to text messages were 9-times higher in apprentices performing brick and block masonry than apprentices performing other types of masonry (OR = 9.87; 95% CI = 1.28–76.02,  $P = .028$ ).

The variance accounted for by the multivariable logistic model was reasonable (Nagelkerke R-square = 0.44) with a non-significant Hosmer and Lemeshow test indicating good fit between observed and predicted classifications ( $P = .67$ ). The model was able to correctly classify 92% of those who responded to text messages and 68% of those who did not, for an overall success rate of 85%. Of note, sex, apprenticeship year, masonry setting, and the interaction between masonry work performed most often and study group did not increase odds of predicting who would respond to text messages, thus did not enter the model.

**Table 4**

Ergonomics knowledge text messages: percentage of responders and percentage answering correctly by group. Asterisk denotes item in which percentage responding differed significantly between groups ( $P < .05$ ). There were no significant differences between the groups for responding correctly.

Question posed in Ergonomics knowledge text	Ergonomics		Ergonomics + Safety Voice	
	Response rate	Responders answering correctly	Response rate	Responders answering correctly
Are you, the worker, part of the ergonomics triad that defines ergonomics?	70%	100%	53%	100%
Is stretching the most important component of ergonomics?	69%*	59%	37%*	58%
Do you think that masons have high rates of over exertion injuries?	22%	100%	28%	93%
Does the A in HARP stands for Awkward Postures?	49%	70%	50%	60%
Will staying fit alone be enough to prevent an injury at work?	61%	96%	46%	87%

#### 4.3. Percentage of responders/correct answers to individual ergonomics knowledge text messages

Table 4 displays percentage of responders per group to each ergonomics knowledge text message. It includes the response rate and, for responders, the proportion in each group answering the question correctly. Chi-square analyses revealed that the percentage responding in the Ergonomics group was significantly greater for only one of the five ergonomic knowledge text messages ( $P = .004$ ). There was no discernable trend in either group to respond more or less often across the 6-month time period. Percentage responding correctly did not differ among groups. However, the text messages were useful reinforcement of knowledge for two of five text messages in which percentages answering correctly in each group were relatively low.

#### 4.4. Percentage of responders/correct answers to individual ergonomics behavioral text messages

Table 5 displays percentage of responders per group to each text message about an ergonomics behavioral action. It includes the response rate and, for responders, the proportion in each group affirming implementation of the behavior. Chi-square analyses

**Table 5**  
Ergonomics behavioral action text messages: percentage of responders and percentage affirming the behavior by group. Asterisk denotes item in which percentage responding differed significantly between groups ( $P < .05$ ).

Question posed in Ergonomics behavioral action text message	Ergonomics		Ergonomics + Safety Voice	
	Response rate	Responders affirming behavior	Response rate	Responders affirming behavior
Have you 'Shifted into Neutral' today?	56%	83%	53%	85%
This week have you practiced having your nose follow your toes when you bend or lift?	56%	83%	47%	83%
Have you varied your shoulder positions throughout the day to reduce the number of chicken wing postures?	61%	92%	46%	91%
Are you aware of your wrist postures when handling materials? Using neutral wrist postures will save you from carpal tunnel syndrome and other wrist injuries.	63%*	100%	32%	94%
This week have you considered safe ways to manage lifting such as avoiding twisting and other awkward postures or keeping materials close to your body?	56%*	100%*	10%	80%
Are you using different postures throughout the day, such as sometimes squatting and sometimes bending within the green zone?	49%	90%	36%	94%
How you grip brick and block is called "coupling". Do your gloves fit snugly so that you have good coupling with the brick or block?	66%*	93%	40%	85%
Using two hands to lift CMU halves the weight lifted by each arm and lets your shoulders rest. Are you sometimes lifting with both hands instead of just one?	51%	96%	32%	81%
Have you practiced standing and bending backward throughout the day?	59%	84%	42%	86%
Material handling equipment such as mortar silos and forklifts are Engineering Solutions. Have you observed Engineering Solutions on your current job?	42%	83%	42%	91%
Have you observed Administrative Solutions on your current job site, such as staging materials close to users or rotating workers to reduce fatigue?	34%	67%	40%	70%
Pre-stocking supplies and scheduling to utilize equipment optimally are Administrative Solutions. Have you observed these solutions on your current job?	46%	90%	40%	80%
Have you used any Work Practice Solutions this week such as using adjustable scaffolding or using good body postures?	17%	75%	6%	67%
Wide stances and scissor stances provide stability. Are you using a wide base or scissor stance to provide stability, especially when lifting?	42%	89%	38%	89%
Did you plan your lifts today to help minimize the risk of an injury to your muscles, tendons and discs?	54%	83%	35%	88%

revealed that the percentage responding in the Ergonomics group was significantly greater for 3 of the 15 ergonomics behavioral text messages (all  $P < .015$ ). There was no discernable trend in either group to respond more or less often across the 6-month time period. Among responders, the percentage affirming implementation of the behavior was significantly greater in the Ergonomics group for 1 of the 15 text messages ( $P = .029$ ). In general, however, apprentices responding to behavioral action text messages tended to affirm using the behavior in large percentages in each group.

#### 4.5. Percentage of responders/correct answers to individual safety voice knowledge text messages

Table 6 displays percentage of responders in the Ergonomics plus Safety Voice group to each text message about safety voice knowledge. It includes the response rate and, for responders, the proportion within the group answering the question correctly. Although the response rate to the initial text message was the largest of all 14 of the texts, beyond this initial text message, there was no discernable trend to respond more or less often across the 6-month time period. Those who did respond tended to do so correctly in high proportions.

#### 4.6. Rating of text messaging at the conclusion of the SAVE evaluation

The majority of apprentices who rated text messaging value ( $n = 86$ ) strongly agreed ( $n = 32$ , 37%) or agreed ( $n = 27$ , 32%) that the texts helped reinforce the SAVE program materials and concepts. One apprentice commented, "Text messaging can be a problem," but did not say why. Other relevant text message comments included: "Thank you for the ergonomic reminders!!" and "The text messages weren't all too informative, I was always asked basic yes or no questions and the answer for most part was always yes. Working on my posture was really up to me and my understanding of posture, there's no way in telling whether I'm doing well or just hurting myself worse."

#### 4.7. Participation rates of logistic text message reminders to return of study surveys

Over the entire study, we mailed 404 surveys to apprentices for the evaluation of SAVE over the six-month follow-up period, which resulted in an initial response rate of 28%. With 683 text reminders sent (up to three text messages per person per survey), we increased the response rate to 64%. With the final verbal or email reminders by instructors at each center, the final survey count was 320 for a response rate of 79%. In addition, we had extended text conversations with 39 apprentices to resolve issues with such logistics details as changes of address, resending surveys, and ensuring gift cards for study participation were received.

## 5. Discussion

Other researchers in public health have reported a wide range of text response rates ranging from 22% to 100% (Kannisto, Koivunen, & Välimäki, 2014). Although few occupational health studies have used text messaging, Burstrom et al. (2016) reported a mean response rate of 93% when using text messaging to determine incidence of low back pain among mining workers. The overall response rate in the current study of 61% indicates that masonry apprentices were responsive to the SAVE text messages. However, we found that the Ergonomics only group had a higher response rate (70% vs 52%) than the Ergonomics + Safety Voice group. The lower response rate may be because the Ergonomics + Safety Voice group had a significantly smaller proportion of brick and block masons than the Ergonomics group. Because most of the text messages focused on ergonomics content, the majority of text messages were the same for both groups. However, the Ergonomics + Safety Voice group received additional Safety Voice text messages. It is possible that fatigue due to the larger volume of text messages in the Ergonomics + Safety Voice group resulted in some apprentices in this group "tuning out" the additional text messages. It is also possible that the safety voice content of the addi-

**Table 6**

Safety Voice knowledge text messages: percentage of responders and percentage answering correctly in the Ergonomics + Safety Voice group.

Question posed in Safety Voice knowledge text message	Response rate	Responders answering correctly
It is just as important to have safety voice skills as it is to learn your trade skills. Do you agree?	60%	100%
Studies show that masons have the most severe injuries when they are erecting or dismantling scaffolding. Are these injuries preventable?	52%	96%
Employers must provide information about hazards on the worksite. Is it true that it is your responsibility to be familiar with the hazards and know what to do about them?	44%	96%
Do you know the hierarchy and who to go to with safety concerns?	40%	100%
Over half of all communication is non-verbal. Is your facial expression an example of non-verbal communication?	48%	92%
Problem solving is your PASS to speak up. Does PASS stand for Problem, Advice and Safety Solutions?	32%	81%
Is it true that there can only be one safety issue in a given situation?	43%	88%
To really understand what a safety issue is, should you think about why is the issue happening?	42%	100%
Is it true that you can find hazard alerts online?	36%	94%
Is it true that a short term solution is always better than a long term solution?	38%	100%
Do you have the control to get an ergonomic hand trowel?	42%	67%
Is it true that you should consider what barriers might exist for a solution?	24%	100%
Can conflict bring new ideas and promote progress?	40%	90%
Does the ABC model for conflict resolution stand for All, Be, Choice?	44%	86%

tional text messages may have affected the response rate. As acknowledged by the HBM, health behaviors are more resistant to change than knowledge. Therefore, participants may have avoided responding to safety voice text messages that asked them to confirm whether they had exhibited behaviors that would support the application of a safety voice. Yet, the text messages, even if not responded to, may still have served as a cue to action to accept a recommended risk-reduction action.

It is not clear why high school graduates were more likely than more highly educated groups to respond to text messaging, when controlling for other co-variables. One explanation for this discrepancy may be the novelty of receiving health information/education by text message in those at lower education levels. It has been reported previously in a population-based study that individuals with lower educational levels are less frequently exposed to health information via digital technologies, such as text messaging (Shen et al., 2018). If this was the case with our sample, apprentices with lower educational attainment may have not reached the saturation point with receipt of text messages, thus may have been more likely to respond to study messages.

We did not collect information about wireless carriers or phone type in the study population, so were not able to analyze whether these factors affected the responses. However, before conducting the current study, we surveyed a random sample of apprentices ( $n = 35$ ) about smartphone use. We found that smartphones were commonly used both privately (80%) and at work (77%), and that apprentices used their mobile phones for text messaging several times a day, (94%) (Hess et al., 2016) With this reported high rate of texting use and since every participant agreed at enrollment to be texted, we considered that wireless carrier and cellphone type would not affect the response rate.

Knowledge retention was high with 58–100% of apprentices responding to text messages correctly for the Ergonomics group and 67–100% for the Ergonomics + Safety Voice groups. Retention did not decrease over the study period, which suggests that in line with HBM tenets, text messages supported maintenance of foundational elements to understand susceptibility to injury and perceived benefits of adopting sound ergonomic work practices. Interestingly, the one text message that both of the intervention groups had the lowest percentages (59% and 58%) answering correctly was a text from SAVE ergonomics content that asked, “Is stretching the most important component in ergonomics?” SAVE training emphasized that while stretching programs are common in construction, other solutions are often more important and effective for reducing injuries. The one text message with a low percent correct from SAVE safety voice content asked, “Do you

have the control to get an ergonomic hand trowel?” While 67% percent responded “yes,” those responding “no” may have previously purchased a trowel and did not feel it was possible to purchase a newer, ergonomic trowel at that time.

In general, the current study results suggest that text messaging may successfully and efficiently reinforce both ergonomic knowledge and safety voice concepts. However, it is not clear whether self-selection bias may have contributed to these positive findings. Those who responded retained more concepts than the non-respondents, who, by nature, we could not measure. Moreover, targeted, customized texts have been reported to be more effective than generic messages (Head, Noar, Iannarino, & Grant-Harrington, 2013). In line with this previous research, the specificity of our text messages, which emphasized masonry tasks and specific key points from the SAVE program, was an important element in the success of our text message refresher training.

Ergonomics behavior affirmation was reported to be high for both the Ergonomics (67–100%) and the Ergonomics + Safety Voice group (67–94%), and also did not change significantly over the study period. Adoption of positive behavior is the ultimate result of occupational health and safety training (Robson et al., 2010), such as apprentice masons maintaining scaffold height to allow material handling between knee and shoulder height. Although we could not confirm whether behavior actually changed through text message responses, the HBM suggests that perception of the effectiveness of an action to reduce the threat of injury is necessary in order for the worker to accept the recommended health action, and cues to action are important to reinforce taking action. As such, we addressed behavior change with proxy measures, such as, “During the past week have you worked on adjustable scaffolding?” Aside from the obvious limitations of not being able to directly observe apprentices at the worksite, we feel responses to text messages affirming recommended health actions at least indicated acceptance of the importance of such actions to health.

An additional use of text messaging in SAVE was for study logistics purposes, such as reminding participants to complete mailed study outcomes questionnaires. While Keding, Brabyn, MacPherson, Richmond, and Torgerson (2016) reported that texting was not effective for improving questionnaire compliance, we found that texting improved our response rate. The logistical text messages and personal communications with text messaging appeared to motivate some participants to better comply with the study protocol. Over the entire study period of 6-months, our overall response rate rose from 28% to 79% using the reminder text messages. These reminders more than doubled our response rate,

which reduced the probability that attrition from non-response would have a large detrimental effect on study evaluation.

Finally, the use of the text messaging service was critical for this current study. Automatically scheduling each center to send the text messages at set times, to receive and record the responses, and to respond accordingly was made easier with the service. The reminder text messages were automated to be sent shortly after surveys were mailed to the participants, and, subsequent reminders were not sent to participants who had already returned their survey. Different text services may have various options as far as text organization or data storage and data downloading or formatting. Text messaging services may not be designed for specific research purposes but rather marketing, so some refinement of the texting protocols and methods had to be considered. For example, we had to modify our text formats to have a simple yes/no response and to have unique characters such as “ay” or “an” for each text to indicate yes/no for the service we used to be able to record the data properly. In addition, the data files from the text messaging software had to be downloaded and transcribed to prepare them for analysis as they were not in a usable format.

This current study had some limitations. For example, the content of the texts requiring a response might have been too basic. Due to constraints with how text message responses were obtained, each message needed to be brief and required only a yes/no response to be able to record the response. This limited our ability to assess higher-order knowledge and behavior changes, but still allowed for the text message to reinforce content. As previously mentioned, we were unable to directly evaluate whether behaviors assessed were actually displayed on the worksite. Thus, we cannot account for the effect of social desirability affecting the truthfulness of responses to our text messages about health behaviors. As with other studies using text messages for health-related behaviors, this is simply a phenomenon that must be accepted as a possibility. Also, there was potential selection bias because the apprentices enrolled in SAVE were from training center sites where instructors agreed to participate and that had at least six apprentices enrolled. Finally, due to resource constraints, we were not able to continue the study evaluation beyond 6-months so maintenance of longer-term benefits was not assessed. Dissemination efforts of the SAVE program and interactions with instructors identified additional dissemination of ergonomics and safety voice training opportunities with journey-level masons and other sub-trades, so further work is possible.

## 6. Conclusions

In conclusion, the response rate in this study suggests that text messaging may effectively provide secondary ergonomics and safety voice refresher training and promote the application of learned material. Training knowledge appears to be maintained over a six-month period. Text messaging worked well for study logistics, which may be applicable to other occupational safety and health programming. Using a text messaging service can help occupational health and safety trainers and practitioners consider campaigns for promoting use of knowledge and skills learned in training with minimal cost and effort. Further research and evaluation of text messages for ergonomics and safety should be conducted.

## 7. Practical applications

The prevalent use of text messaging creates opportunities to reinforce health and safety education and engage workers, especially for populations that may be at various locations over time, such as construction sites. Health and safety instructors and prac-

tioners should consider the use of text messaging to reinforce recommended health action.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jsr.2020.04.007>.

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