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Construction Work Practices and Conditions Improved After 2-Years' Participation in the HomeSafe Pilot Program

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National Institute for Occupational Safety and Health grant 1 RO1 CCR814123-01 supported this investigation in the HomeSafe pilot program sponsored by the Occupational Safety and Health Administration and the Home Builders Association of Metropolitan Denver.

This study reevaluated changes in job-site safety audit scores for a cohort of residential construction workers that had protracted exposure to the HomeSafe pilot program for 2½ years. The investigation was a repeated measure of a cohort study underway in the six-county metro area of Denver, Colo. The larger study was a longitudinal, quasi-experimental design with a cohort of residential construction workers within the HomeSafe strategic partnership between Occupational Safety and Health Administration Region VIII and the Home Builders Association of Metropolitan Denver (HBA). Audits were conducted on residential construction sites. Study subjects were construction workers employed by partner or control companies within the study. Repeated measures of 41 companies showed significant improvement ($p=.01$) in audit scores, increasing from 71.8 to 76.8 after 2½ years in the program. HomeSafe companies outperformed controls ($p=.01$) for both the retest group and previously unaudited HomeSafe companies. Prolonged exposure in the HomeSafe pilot program resulted in improved audit scores for companies within the program for at least 2 years.

Keywords: audit scores, HomeSafe pilot program, residential construction

APPLIED STUDIES

The construction industry claimed 1190 lives due to accidental death in 1999.[1] This industry ranks second behind only truck driving for the leading fatality rate among American industries. Construction employs 6% of the American workforce, yet it claims 15% of the workers' compensation (WC) dollar, 10% of all disabling injuries, and 20% of all workplace fatalities.[1–4] The construction industry was responsible for 50% of the 717 work-related deaths due to falls in 1999. Construction-related falls are now the second leading cause of death in the American workplace, surpassing homicide rates for the first time in 6 years.[1,2] The National Institute for Occupational Safety and Health reports that the fatality rate for construction workers was 15.3 per 100,000 workers when evaluating fatality data from 1980 to 1995.[5]

Residential construction comprises approximately one-half of the construction industry.[6] Dement and Lipscomb found high injury and illness rates in a cohort of residential construction workers between 1986–1994 provided by the North Carolina Home Builders Association. Overall injury and illness and lost workday rates were 16.4 incident rate and 10.78 severity rate per 100 full-time equivalent workers.[7]

In an attempt to reduce the incidence, severity, and fatality rates in the Colorado home building industry, Occupational Safety and Health Administration (OSHA) Region VIII and the Home Builders Association of Metropolitan Denver (HBA) collaborated to develop the HomeSafe pilot program. The HBA Safety Committee studied the injury and death statistics for construction in Colorado and across the nation. They identified the 10 priority areas including the major safety risks and hazards present in the residential homebuilding process, which became the central focus of the HomeSafe 10-point guide booklet.[8] The 10 points covered are

(1) safety policy;
(2) personal protective equipment (PPE);
(3) scaffolding;
(4) ladders;
(5) construction electrical power and power cords;

(6) access and housekeeping;
(7) open holes and unprotected sides and edges;
(8) fall protection;
(9) excavations and trenching; and
(10) power tools and motorized equipment.

HomeSafe represents a safety and health strategy focused on those points, presented in a simplified manner, easy to use, and readily available to workers. Member companies had representatives attend a 3-hour training and orientation session sponsored by the HBA. The representatives then implemented the program in their companies. The HomeSafe pilot program and the contents of the *HomeSafe Pocket Guide* are comprehensively reviewed in previous publications.[9–11] Bigelow et al. described the results of initial work-site assessments using the same on-site, behavior-based safety audit administered in this study.[9]

The HomeSafe audit tool measures compliance with the HomeSafe 10-point list using 87 questions or items, graded all-or-none, to evaluate workplace practices and environmental conditions on each residential construction work site. Results from the initial assessment revealed no significant differences in pre- and postaudit scores between those workers in the HomeSafe program compared with those not in the program. Previous audits had been performed at 195 work sites throughout the Denver metro area. The initial evaluation compared audit scores from 60 HomeSafe partner companies with 135 non-HomeSafe companies. However, there was a significant difference noted between HomeSafe partner postaudit scores and controls. It was felt that partners might have needed additional time in the program to implement changes resulting in improved work practices and measurable outcomes. A detailed discussion of this instrument and results is available.[12] The present study reassessed changes in audit scores following 2 years participation in HomeSafe for a portion of those contractor firms audited previously, as well as additional firms assessed for comparison with the audited ones.

METHODS

The purpose of this study was to evaluate whether the effect of time in the program made a difference in the performance of HomeSafe partners' audit scores. Although many companies representing a variety of trades participated in the HomeSafe pilot program, not all were selected for participation in this reassessment study. Trades were identified and defined by the Standard Industry Classification (SIC) of the workers interviewed. A list of the companies audited 2 years previously was obtained from the HBA Denver office and prior Colorado State University investigators. Not all of those companies could be contacted for this current study for several reasons, including withdrawal from the program, business failure, or change of phone listing. The companies were contacted by phone to request participation. Company representatives were asked not to notify the work crew that the program auditor would be arriving on the site on the scheduled day. An experienced auditor in the HomeSafe pilot program trained the field investigator in using the previously developed HomeSafe audit tool. All audits were performed by a single auditor in this study for consistency of evaluation.

The study population was divided into three groups: (1) the retest group consisted of home-builder companies that had been evaluated 2½ years previously (1998) and continued to participate in HomeSafe; (2) the control group consisted of home-building companies that were not participating in the HomeSafe pilot program (controls were not matched to previous controls); and (3) a previously unaudited group, which consisted of home-building companies that had been HomeSafe partners for approximately 2½ years but were not audited previously. In many instances control subjects under a different general contractor were sought at the same housing project at which a participant was audited. These companies were not members of the HomeSafe program, so permission to conduct the HomeSafe audit was obtained from on-site employees. A similar procedure was followed in the case of the previously unaudited group. Permission from the previously unaudited firms was solicited by telephone, and then audits of these companies were conducted during the same period as that for the retest group.

Generally, however, only one company audit was administered at any given site per study group. A site was defined as a single-family home under construction. After entering a work site, the audit administrator announced to the company that a HomeSafe audit was going to be performed. One company employee was identified to answer the few questions from the audit form. These questions included information about the employee's knowledge of the HomeSafe program and the occurrence of company safety meetings. The investigator then systematically evaluated the work-site conditions and work practices using the HomeSafe audit tool, covering up to 87 items applicable to the 10 sections of the HomeSafe program. Audits were administered between May and August 1999. A total of 107 audits was performed on job sites from within the six-county region of Denver. Workers in 17 trade classifications were assessed.

RESULTS

Data from the audit forms were entered into a computer database and analyzed using the Statistical Package for Social Sciences (SPSS®) and SAS®. The score of each audit was determined by dividing the total number of "yes" responses by the total number of questions that were applicable; this ratio was then multiplied by 100. A high score was related to a high level of compliance with the program. The overall audit scores were normally distributed in this study. The auditor approached different company representatives ranging from owners to laborers. The response rate for the audit was 100%, with 41 audits for the retest group, 41 for controls, and 25 for the previously unaudited group (Table I). All of the participants were involved in single-family dwelling construction.

After arriving at the designated job site, the auditor selected the first available worker to initiate contact. This meant a worker who was not engaged in active work using power equipment or working on an elevated platform and who acknowledged the auditor. Laborers were by far the most frequently approached respondents (38 [of 41] in the retest group, 25 [of 25] in the previously unaudited group, and 40 [of 41] in the control group). If the identified company representative could not answer these questions in English, another person was identified to translate into Spanish.

The distribution of trades among the three test groups is seen in Table II. The greatest number of audits (16, or 15%) was conducted among the electrical trades, SIC 1731, followed by 12 (11%) each for framing, SIC 1751, and excavation, SIC 1794. The greatest number of audits among the trades within the control group was electrical, with 8 (19.5%). Among the previously unaudited group the greatest number of audits (4, or 9.75%) each were obtained in the framing, excavation, and electric trades.

In the Colorado region the construction industry employs a large number of Hispanic workers, many of whom speak only

Spanish. In this study 66.4% (71) of the respondents were English-speaking and 33.6% (36) were Spanish-speaking. There was an approximately equal distribution of Spanish-speaking workers across the three sample groups.

HomeSafe groups' audit scores were significantly greater ($p<.01$) than control group scores, (Table II). The total mean score for the retest group was 76.0, for the previously unaudited group 73.7, and for the control group 66.9. In all cases in which comparisons could be made across trades, except for heating, ventilation, and air conditioning (HVAC), the control group's scores were lower than the retest group's scores.

When assessing mean scores within each of the HomeSafe 10-point sections, the retest and previously unaudited group outperformed the control group in nearly every area (Table III). The retest group scored highest in the use of fall protection (89.4) as did the previously unaudited group (91.7), whereas controls ranked highest in ladder usage (78.5).

One-way analysis of variance was used to evaluate companies in the retest group against previously audited group scores.[9,12] Matching was used when possible to see whether the retest group differed with additional time in the HomeSafe program compared with previous posttest group scores captured 2 years earlier. The matched companies were evaluated using paired t-tests. The retest group as a whole had a significantly higher mean score (76.8) than the pretest group (71.2) and the posttest group (71.8) from 2 years previously ($p=.04$). No significant differences were observed in score gains among trades ($p>.05$). However, the trade with the largest number of matched audits was roofing (6), with nearly significant audit score gain seen ($p=.069$). The mean score did improve 11.8% from 79.7 to 91.5. The largest score gain (30%) among trades was in exterior trim, rising from 61.1 to 91.1 ($p=.059$). Positive gains in audit scores also were noted in drywall (11.9%), roof gutter (10.4%), concrete flatwork (5.4%), electrical (3.1%), and 2% for framing and insulation. Those trades performing at lower scores included drainage/pipelines (−20.9%), HVAC (−10.6%), and concrete foundation (−2.8%). The trades cumulatively achieved a 42.4% advance in scores.

DISCUSSION

Safety programs cannot be proven effective without appropriate evaluation.[13] Direct observation is an established method to determine the effectiveness of safety programs.[14–17] The audit tool used in this study was an on-site, behavior-based observation tool to assess safety hazards and safety compliance in the residential construction industry.[9,10,12] In the safety and health industry the most common instruments used to record and translate safety performance information are questionnaires, checklists, and audits.[12] The use of these instruments is well-established.[17–20] The purpose of using the audit tool in this study was to collect data to establish a link between participation in the HomeSafe program and increased safety performance.

This study was a quasi-experimental cohort investigation that identified 41 previously audited companies that continued in the HomeSafe pilot program for an additional 2 years plus an additional 25 not-previously-audited companies that had also been in HomeSafe for more than 2 years. A control group of 41 non-HomeSafe companies were selected for comparison with the 2 HomeSafe groups; a total of 107 audits were performed. The present study supports the assertion that adequate program exposure intensity, frequency, and duration can positively affect work behaviors.[18] In this study audit scores rose significantly with additional time in the program. Previous auditing of newly enrolled HomeSafe partners yielded a nonsignificant difference from the mean pretest score after 4 months in the program. Two years later, 41 of those previously audited partners were identified and reaudited. The present study found significant increases in the mean scores of matched HomeSafe partners, with mean score rising from 71.2 to 76.0 ($p<.002$). No significant differences were seen between the retest group and previously unudited group ($p=.23$). Even the previously unaudited group significantly outperformed the controls ($p=.05$).

When the program was launched in early 1997, more than 100 home-building companies attended that initial session. Subsequent to that initial training and orientation session, an additional 17 sessions were conducted over the next 3½ years, which were attended by more than 400 companies and 1500 representatives.

The minimum exposure to HomeSafe duration has been 2½ years since the initial 3-hour training and orientation session for the retest group and 2 years for the previously unaudited group. The initial training and orientation session HomeSafe exposure was directed at select company representatives who were "at-will" to implement the program as they chose within their own companies over the next 2 to 2½ years. Partners were encouraged to secure *HomeSafe Pocket Guide* booklets for all employees and the *HomeSafe Tailgate Talks* field-training manual and to attend additional training through the HBA and OSHA.

Companies that employed *HomeSafe Tailgate Talks* to use with worker training were able to systematically complete the 10-point list repeatedly. This manual was made available through the HBA in both Spanish and English for an additional fee. Each topic area is complete with a teaching syllabus and test for performance evaluation and record keeping. *Tailgate Talks* also provides "hardhat stickers" designating each of the 9-point hazard categories successfully completed. When the worker completed the topic training he or she received a hardhat sticker. Using performance measures increases intensity of the training, whereas, if training did not include evidence of learning the intensity would be reduced and thus not as powerful.

Auditing over the pre- and retest was carried out in a similar distribution throughout the six-county Denver metro area in both studies. However, some differences in the distribution do exist. Previous audits had been done at 90.9% single-family home sites, whereas 100% of the most recent audits were carried out at single-family home sites. The previous investigator also evaluated apartment, condominium, and townhouse sites. The investigative team does not believe this sampling variation positively or negatively impacted audit scores.

The geographic distribution was also slightly different between these two studies, although housing starts in the Denver metro area were reported to be nearly the same, approximately 25,000 each for both 1998 and 1999 by HBA. There is little reason, however, to believe that the same work practices and exposures were not present in each geographic area.

Respondents answering the audit questions differed between the two testing times. The previous investigator identified 36% as owners, 23.8% as foremen or supervisors, and only 40.1% as laborers.[12] In the most recent audit the investigators found 96.2% of all respondents from the three test groups were laborers and only 2.8% were supervisors. Only one company owner answered questions during a job-site audit. This sampling variation most likely positively affected the quality of the audit. Management and laborers often have differing opinions about practices, procedures, and knowledge of work. Front-line workers probably best represent knowledge about the daily practice of those exposed to the hazards of residential construction.

TABLE I. Descriptive Statistics of Study Population Retest, Previously Unaudited, and Control Groups

Characteristics of the Study Groups	Retest Group (n = 41)	Previously Unaudited Group (n = 25)	Control Group (n = 41)
Respondent's job title			
Owner	0	0	1
Foreman/supervisor	3	0	0
Laborer/employee	38	25	40
Heard of HomeSafe?			
Yes	34	20	2
No	7	5	39
Use HomeSafe as their training program?			
None	7	6	41
Weekly with general contractor	33	19	0
Weekly with the company	1	0	0
Knows who the safety coordinator is?			
Yes	33	21	23
No	8	4	18

Respondents demonstrated increasing awareness of HomeSafe from the initiation (1997) of the program. Initially, the pretest group (22.2%) and the posttest group (60.0%) reported that they had heard of HomeSafe. The audit showed 81.8% awareness of HomeSafe among the two study groups. This is consistent with increasing audit scores. One would expect a greater awareness of the program in the residential construction industry in the Denver metro area given the industrywide attention and national focus on this novel pilot program.

Despite these conditions, the construction industry is very dynamic in terms of competing priorities, available resources, employee turnover, short-term projects, hazards and risks, and so forth. The general contractors control building projects and can monitor changes and act to ensure that their new subcontractors are aware of the components of the HomeSafe program. The assumption that the general contractors and subcontractors are manageable may be more realistic, but training their employees and representatives about using the HomeSafe program is the necessary link to achieve a fully integrated success. On several occasions during the auditing process subcontractors indicated no knowledge of the HomeSafe program even though their general contractor or midcontractor was a participant. It was apparent that some general and subcontractors who joined the program to improve safety performance on their work sites had not ensured delivery of HomeSafe to their workers who were most at risk with unsafe work practices and job site hazards. Despite the numerous avenues by which one might be exposed to the program, greater effort is still necessary to assure that all employees are informed.

The most recent audit suggests that an increasing number of Hispanic workers are present among all trades. Previously 92.5% of all respondents spoke English; of the most recent groups of respondents only 66.4% spoke English. Some companies have positioned themselves to be very competitive solely on the basis of hiring increased numbers of minorities. The price per unit paid

TABLE II. Mean Audit Scores Among All Trades in the Retest, Previously Unaudited, and Control Groups

	Retest Group		Previously Unaudited Group		Control Group		Total
Trade	Mean (n)	Std. Dev	Mean (n)	Std. Dev	Mean (n)	Std. Dev	Mean (n)
Frame	79.0 (3)	13.6	65.7 (4)	4.3	66.1 (5)	12.3	69.2 (12)
Roof	91.8 (7)	7.4	84.8 (2)	7.8	53.1 (2)	13.9	83.5 (11)
Drywall	78.5 (5)	10.2	60.0 (4)		72.8 (1)		75.0 (7)
Plumbing	—		–		68.0 (5)		68.0 (5)
Excavation	73.0 (2)	2.8	64.9 (4)	5.8	57.6 (6)	10.7	62.6 (12)
Exterior trim	91.1 (1)		83.7 (1)		—		87.4 (2)
Insulation	63.9 (4)	10.7	—		—		63.9 (4)
Concrete foundation	71.5 (3)	6.1	—		62.2 (4)		66.2 (7)
Roof gutter	68.4 (2)	3.4	—		—		68.4 (2)
HVAC	69.6 (3)	13.6	58.3 (1)		71.1 (4)	11.4	68.9 (8)
Electric	84.5 (4)	10.7	84.9 (4)	6.2	71.8 (8)	14.3	78.3 (16)
Concrete flatwork	66.1 (2)	27.5	74.0 (2)	28.0	—		70.0 (4)
Interior trim	—		79.3 (1)		—		79.3 (1)
Paint	—		73.7 (3)	14.0	73.2 (6)	10.9	73.3 (9)
Drainage	62.2 (3)	10.7	81.0 (2)	8.5	—		69.7 (5)
Landscaping	66.7 (1)		—		—		66.7 (1)
Fireplace installation	67.0 (1)		—		—		67.0 (1)
Total	76.0 (41)	13.6	73.7 (25)	13.2	66.9 (41)	13.7	72.0 (107)

TABLE III. Mean Audit Scores (Number of Audits) Within HomeSafe 10-Point Sections Among the Retest, Previously Unaudited, and Control Groups

HomeSafe Sections	Retest Group		Previously Unaudited Group		Control Group		Total Mean (n)
	Mean (n)	Std Dev	Mean (n)	Std Dev	Mean (n)	Std Dev	
PPE	83.2 (41)	29.2	75.9 (25)	32.2	73.0 (41)	33.1	77.6 (107)
Scaffolding	76.2 (19)	19.6	87.5 (2)	17.7	67.4 (10)	15.3	74.1 (31)
Ladders	88.0 (26)	12.1	85.0 (15)	9.2	78.5 (28)	10.2	83.5 (69)
Access/housekeeping	79.3 (41)	27.6	72.7 (25)	27.6	60.0 (40)	26.9	70.4 (106)
Open holes	25.0 (4)	50.0	50.0 (8)	53.5	18.8 (8)	37.2	32.5 (20)
Fall protection	89.4 (9)	18.5	91.7 (2)	11.8	75.0 (2)	35.4	87.5 (13)
Excavation	85.4 (8)	14.0	76.3 (6)	18.8	69.7 (10)	10.1	76.6 (24)
Power tools	64.5 (41)	45.8	74.0 (25)	43.6	72.7 (41)	40.5	69.9 (107)
Power cords	76.3 (24)	25.0	73.5 (18)	21.7	64.5 (31)	22.4	70.6 (73)
Overall	76.0 (41)	13.6	73.7 (25)	13.2	66.9 (41)	13.7	72.0 (107)

for building has gone down due to the fierce competition in the Denver metro homebuilding market.

In the previous study, framers, roofers, and masonry trades made up the largest proportion of the study sample: 31, 8, and 8%, respectively. In this study framers, roofers, and masonry trades comprised smaller proportions of 11.2, 10.2, and 0% respectively. Carpenters continue to be the largest trade in construction, both residential and commercial.[21] Carpenters are exposed to a great number of risks including falls, electrocutions, and being struck by objects. They are a targeted trade within HomeSafe. The majority of the 10-point list applies well to this trade. Each trade has unique risks, and only portions of the HomeSafe 10-point list may apply to them specifically. The HomeSafe benefits are meant to apply across all trades for residential construction at large. The sample variability measures compliance to practices and conditions denoted in the HomeSafe 10-point pocket guide.

Falls are the main cause of fatalities among construction workers.[1] Dement and Lipscomb reported that the highest death rates due to falls were among roofers, insulators, carpenters, and drywall workers.[7] The HomeSafe content was designed first and foremost to save lives. These four highest-risk trade groups all demonstrated positive gains compared with the previous study. Given the emphasis placed on fatality prevention, the mean scores of 89.4 and 91.7% in the most recent audit for fall protection compliance by the two HomeSafe study groups is encouraging. Fall protection ratings included personal fall arrest systems, scaffolding, and ladder use; these three HomeSafe categories received the highest scores of all hazard classes on the 10-point list. The HomeSafe program appears to have increased safe work practices and conditions to reduce fall risks and hazards.

OSHA has specific interests in outcome measurements of the HomeSafe evaluation project that are focused on overall injury and fatality rates (injury rates, severity rates, lost workday incidence rates, fatality rates). These rates will be forthcoming later this year. However, it is worth stating that injury rates reflect an adverse consequence of a postbehavior or condition event and not the occurrence of a safe work practices event.[19] This study was an attempt to evaluate work practices and site conditions to identify daily preventive measures. The authors believe that this type of emphasis must continue to support models, such as HomeSafe, that are designed to establish and improve safe work behaviors and site conditions that ultimately may reduce negative outcomes such as injury and fatality.

All study respondents were administered the same HomeSafe audit instrument using the same administration protocol. In the most recent measurement a single investigator administered the audits to all 107 companies, thereby reducing variability in scores due to differences (i.e., preferences, knowledge, and biases) among multiple auditors as described by other construction investigators.[22]

HBA was the primary resource for general contractors seeking additional information, training, and materials on HomeSafe. Only recently, the HBA has developed a ''Comprehensive Safety and Health Program for Residential Homebuilders'' that builds on HomeSafe's content and embraces all essential elements of the typical comprehensive safety and health program. The recent safety and health training workshop was well attended by companies seeking ways to improve their existing programs and seize additional benefits within the HomeSafe pilot program.

LIMITATIONS

Although some companies expressed a sincere interest in participating in the HomeSafe pilot program evaluation, most were impartial to their audits in the study. A potential bias of this study was associated with notifying the HomeSafe participants before the inspections were performed. Although company representatives were asked not to notify their employees that the HomeSafe auditor would be arriving on site, there was no way to verify whether the representative actually notified the soon-to-be audited work site. Companies that were notified that the auditor was arriving may have made certain preparations that could have increased the scores on the audit.

On many occasions the study investigator noted that employees would behave differently while the audit was being conducted. Most of these actions were readily identifiable, and those that were observed were not considered as improvements in safety performance during the auditing process. Employees of both HomeSafe participating companies and control companies were observed performing these ''quick-fix'' behaviors. Therefore, any bias associated with this factor of the auditing process likely showed a slight and equal improvement in the safety performance scores among the three test groups.

An issue of concern with data collection was the possibility of observing unsafe behaviors and site characteristics during the time that an audit was performed. The average audit took only 20 to 30 min to complete, depending on the number of hazards present and HomeSafe sections applicable; this variability in time on the job site may have impacted a company's score. Each company was scored solely on observations made within that time. This chance observation was particularly problematic in the residential construction industry, where workers often completed a variety of jobs in the course

of the day. A design change, lack of supplies, or inclement weather may have determined the daily schedule a company followed and may have impacted the work being done on the day of the audit.[23]

The field investigator was familiar with OSHA construction standards and trained in the regulations of the HomeSafe program. Additionally, the HomeSafe program coordinator was available for consultation when questions arose regarding the auditing process, and several trial audits were conducted prior to the beginning of the study auditing.

The HomeSafe pilot program is a cohort of volunteers and not randomly selected representatives of their industry. They may not represent the average residential construction companies. In the initial study HomeSafe posttest findings were significantly higher than controls. HomeSafe partners may represent a group of volunteer construction companies more likely to implement safety and health improvements than nonvolunteer companies; therefore, the findings of this study may not be generalizeable to the industry as a whole.

CONCLUSIONS

The HomeSafe participants in this study have been active in this strategic partnership for an extended time. The HomeSafe program has demonstrated its ability to significantly increase mean audit scores, suggesting that improved work practices and job site conditions have occurred in the Denver, Colo. metro area. The residential construction industry is in dire need of improved work practices and conditions as well as greater participation in structured health and safety programs. The results of this study are encouraging for nonparticipating companies to adopt the HomeSafe program. Exposure to health and safety programs can make a difference in reducing exposures to job-site risks and hazards. This study suggests that longer duration exposure in a program can alter and improve behaviors and conditions. HBA and OSHA continue to look for ways to improve HomeSafe to ensure its effectiveness at reducing accident and injuries on residential construction sites.

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