HHS Public Access

Author manuscript

Saf Sci. Author manuscript; available in PMC 2022 October 01.

Published in final edited form as:

Saf Sci. 2021 October ; 142: . doi:10.1016/j.ssci.2021.105353.

Flow-down of safety from general contractors to subcontractors working on commercial construction projects

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Abstract

Small and medium construction firms have high injury rates but lack resources to establish and maintain effective safety programs. General contractors with exemplary safety programs may serve as intermediaries to support development of smaller firm's safety programs. The purpose of this study was to examine the flow-down influence of general contractors' safety programs on the safety climate and safety behaviors among workers employed by small and medium sized subcontractors. This study collected workers' perception of safety climate and safety behaviors while working on projects with general contractors with exemplary safety programs and other general contractors. We also documented the safety program policies and practices of subcontractors, and recorded the changes in safety policies required from general contractors with exemplary programs. We examined differences in safety program changes between small and medium sized subcontractors. Results showed workers perceived general contractors with exemplary safety programs had stronger safety climates than other general contractors. Smaller subcontractors had less robust safety programs with fewer safety elements than larger subcontractors, and therefore, many of the smaller subcontractors had to adopt more safety policies and practices to work for general contractors than large subcontractors. These findings suggest that general contractors with robust safety programs can serve as intermediaries and influence the development of the safety programs of small sized firms. Future work will need to determine if smaller firms eventually adopt safety policies and practices as part of their permanent safety program.

Keywords

small-sized employer; construction; safety climate; safety management programs; injury prevention; leading indicators

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Declarations of Interest: None

1. Introduction

Safety in construction is complex, due to rapidly changing work environments and unique hazards of the industry (National Institute for Occupational Safety and Health (NIOSH), 2013a; Ringen et al., 1995). The construction industry continues to have high rates of fatal and non-fatal injuries, leading all industries in fatalities in 2015 (CPWR - The Center for Construction Research and Training 2018). Further complicating safety organization is the large number of small and medium sized enterprises (SME): 79% of contractors employ fewer than 10 workers and 98% employ fewer than 100 workers (CPWR, 2013) and smaller-sized enterprises account for a disproportionate number of injuries and fatalities compared to the overall sector (CPWR, 2013). SME owners often lack sufficient safety resources (Schulte et al., 2018) and face financial and organizational barriers to implementing recommended health and safety programs (NIOSH, 2013b). The outstanding question is "how can construction enterprises develop effective safety programs, particularly smaller firms with fewer resources?"

The purpose of this study was to examine the flow-down influence of general contractors' safety programs on the safety climate and safety behaviors among workers employed by small and medium sized subcontractors. This study addressed two inter-related questions posed in National Occupational Research Agenda (NORA) (2018): Can small employers successfully apply flow-down safety requirements on large projects? How influential are well run projects for transferring safety skills and practices to small employers? We tested the hypothesis that small and medium sized subcontractors would improve their safety climate and the safety behaviors of their workers when working on the projects of general contractors with exemplary safety programs. We also examined whether general contractors' expectations of their subcontractors' safety activities influenced the adoption of safety practices into the subcontractors' safety programs.

2. Literature Review

2.1 Safety management programs

There have been a large number of contributing factors associated with the occurrence of accidents and injuries in construction (Haslam et al., 2005). Safety programs are a collection of guidelines and procedures that are intended to reduce risk of mishaps and injuries (Hallowell and Gambatese, 2009). Safety programs typically follow the safety and health regulations of the country. In the United States, Occupational Safety and Health Association (OSHA) enacted the OSH Act General Duty Clause, Section 5(a)(1), which requires employers to provide their workers with a workplace free from recognized hazards likely to cause death or serious physical harm (OSHA, 2020c). National and international regulations and guidelines have been developed to help employers of various industries create safety management programs (BSI Group, 2020; International Organization for Standardization (ISO), 2020). Safety management programs develop good practices in health and safety using a structured, systematic process with continuous improvement (Liang et al., 2020; Kim et al., 2019). These comprehensive programs contain common elements from several domains: management support, worker participation, training, and review (Ismail et al., 2012; Yoon et al., 2013). In 2016, OSHA created recommended practices to help firms develop their safety and health programs, particularly geared toward assisting smaller-sized companies (OSHA, 2016).

Yet despite these recommendations, the evidence for how companies improve their safety outcomes is less clear. Most companies measure their safety improvement by the incidence of injuries and lost time. These lagging indicators of safety are insensitive to change, do not provide timely information, and do not measure barriers to change or actions taken to address workplace hazards (Grabowski et al., 2007; Hinze et al., 2013b; Trethewy, 2003). Leading indicators such as safety walk-throughs and inspections, preplanning task logs, and reports of safety behavior provide more timely and relevant safety information, and have been linked to injury prevention (Choudhry et al., 2009; Institute for Work and Health, 2011; Laitinen et al., 1999; Mikkelsen et al., 2010; Toellner, 2001). These leading indicators are direct measures of safety activities but they do not capture the safety created by work organization and management. Safety climate is a measure of worker's perception of safety (Jazayeri and Dadi, 2017; Zohar and Luria, 2005) and has been associated with safety performance (Choudhry et al., 2009; Gittleman et al., 2010; Sokas et al., 2009). Safety climate has been proposed to measure management commitment to safety, safety communication, and worker involvement in safety efforts (Mohamed, 2002; Seo et al., 2004; Torner and Pousette, 2009), suggesting the structure and delivery of safety programs influence safety climate (Cigularov et al., 2010; Ismail et al., 2012; Kines et al., 2010).

There have been many studies examining the effectiveness of safety programs to reduce work-related injuries (Hallowell and Gambatese, 2009; Robson et al., 2007). Studies have examined effectiveness of individual safety elements and found several elements or factors that interacted with safety: regulations, incentives, production, worker goals, management, and reactive and proactive learning (Guo et al., 2015; Hallowell et al., 2013; Hinze, 2002). Zhou conducted a comprehensive review of construction safety research and found the largest number of studies examined use of safety management systems (Zhou et al., 2015), although there continues to be challenges with measuring effectiveness of safety management systems and various elements of safety programs (Jazayeri and Dadi, 2017; Mohammadi et al., 2018).

2.2 OSHA Partnerships and Voluntary Protection Programs in U.S.

In the U.S., a company's safety performance is generally measured by their injury rate or insurance claims (Hoonakker et al., 2005), but these measures do not provide insight into the effectiveness of their safety program (Sinelnikov et al., 2015). In addition, OSHA does not provide criteria for scoring the quality and effectiveness of employer safety programs. In lieu of a standard scoring method, OSHA has created several voluntary programs for construction contractors to have their safety programs critically reviewed to determine if it meets a high safety standard and considered an exemplary safety management programs. OSHA offers two ways employers can demonstrate a high standard of safety: an OSHA Partnership agreement (OSHA, 2004) between OSHA and one or more participating contractors includes annual reviews and inclusion of a large number of safety standards; and a Voluntary Protection Program (VPP) which requires an extensive review by OSHA of a single firms safety management program and inclusion of a large number of safety policies and procedures (OSHA, 2020a).

2.3 Intermediaries support for safety

Despite the available information available to create a safety management program, many companies lack the resources of time and money (NIOSH, 2013b). This is particularly true of small employers. To overcome the challenge of connecting with SME in order to drive safety improvement, NIOSH has proposed the use of "intermediary organizations" including general contractors who employ small and medium subcontractors (NIOSH, 2013b). Intermediaries are organizations that interact or carry out business activities with companies and may influence the behavior of the company (Cunningham and Sinclair, 2015). In construction, suppliers, general contractors, inspectors, and other companies all interact during the planning and construction phase to complete a construction build. The top down safety requirements of a general contractor can offer a strong financial incentive for small construction firms to improve health and safety in order to successfully "bid" on a general contractor's projects (Hinze et al, 2013a). A review of small business safety programs (MacEachen et al., 2010) concluded that small employers benefit from multi-component occupational health and safety interventions including training, safety audits, engineering controls, and motivational components such as financial incentives. These findings suggest that large general contractors with dynamic multicomponent safety programs can have a positive effect on the safety climate and safety behaviors of their subcontractors through safety "flow-down," the process of exposure to and adoption of new ideas between intermediaries (MacEachen et al., 2010; Lingard et al., 2010), which would be. To date, there has been little formal evaluation of the "flow-down" of general contractors' safety requirements to the construction workers employed by their subcontractors (Sinclair et al., 2013).

3. Materials and methods

We selected a sample of six general commercial contractors identified as having exemplary safety management programs as all have met the requirements to be a part of OSHA Partnerships for Worker Safety and Health. The Associated General Contractors (AGC) of Missouri formed an OSHA partnership (OSHA Strategic Partnership Program for Worker Safety and Health) in 2003 (OSHA, 2020d), and five of the six general contractor participants in the study were participants in the AGC of Missouri OSHA partnership (ENR Midwest, 2010; OSHA, 2020b). The sixth company has a separate OSHA partnership demonstrating their strong emphasis on safety. Therefore, all of the participating general contractors met a standard of an exemplary safety program, in addition to having low injury rate and low insurance claims. We worked with each of the general contractors to select one of their large construction projects for this study with the following criteria: project duration of at least 12 months, expected to employ at least 12 subcontractors of different trades, and each subcontractor expected to work on the project for at least 30 days and employ at least two workers.

We asked each worker on the project to complete two surveys. The first survey, obtained on their first day on the general contractor's project, asked each worker's perceptions of the safety of their general contractor, subcontractor, and other workers on their most recent past project. The second survey, completed after at least 30 days of working on the current project, asked each worker these same questions about the period working under the current (exemplary) general contractor (See Appendix A). Survey completion required 10–15 minutes. The surveys asked workers to provide their demographic information (age, gender, race), the name of the general contractor on their past and current projects, the subcontractor by whom they were employed, dates they worked on the past project, time employed on the current project, and their safety perception of the general contractor, their subcontractor, their coworkers, their crew, and themselves. Workers provided informed consent and were compensated for their participation in completing the surveys. The Institutional Review Board at Washington University School of Medicine in St. Louis approved this project and consent forms.

3.1 Outcome measures: safety climate and safety behaviors

The primary outcome of the study was the worker-perceived rating of the general contractor's safety climate, captured by a modified version of the scale by Zohar and Luria (2005). Secondary outcomes were worker reported measures of their subcontractor safety climate (Zohar and Luria, 2005), co-worker safety climate (perceived safety attitudes of coworkers) (Brondino et al., 2012), workers' individual safety behaviors (Neal and Griffin, 2006), and safety behaviors of their fellow crew members (Kaskutas et al., 2010). The items from each measure were summated and standardized to a score from 0 to100, with higher scores indicating better safety.

3.2 Independent variables: contractor size

We defined each contractor by size based on their average number of employees. Subcontractor size was defined as small (0–50 workers), medium (51–200 workers), or large (more than 200 workers). General contractors were defined as large if they employed 500 or more workers, and small if they employed fewer than 500 workers.

3.3 Subcontractor safety program changes to meet general contractor requirements

We interviewed a representative from each of the current general contractors and reviewed their written safety programs in order to describe the safety practices required of all subcontractors employed on the current projects. We also interviewed and reviewed written safety documents of all of the subcontractors on the current general contractor project to learn about their safety policies and practices, and specifically if their program included the required general contractor safety policies for the project. We categorized subcontractor safety policies and programs that met the requirements of the OSHA, as well as those that exceeded OSHA requirements (OSHA, 2020e). The interview and safety program review were described in a companion publication (Dale et al., 2020). We then compared each subcontractor's safety policies and programs to the general contractor's requirements to identify changes required by each subcontractor to comply with the general contractor's requirements for performing work on the project.

3.4 Data analysis

We reviewed all worker surveys collected at baseline (related to each worker's past project) and those collected after being onsite more than 30 days (referred to as "current" project). From baseline surveys (n=1457), we excluded those with missing data on the past general contractor or subcontractor (n=327), those from past projects run by one of the six current general contractors (n=366), or duplicate surveys (n=1), leaving 763 surveys for analysis. From surveys on the current project, collected after being onsite more than 30 days (n= 1032), we excluded those missing the name of the general contractor or subcontractor (n=21), those who worked less than 30 days on the project (n=115), and repeated current project surveys by the same participants (n=107), leaving 789 surveys for analysis. To compare effects of safety program changes within subcontractors, we restricted the surveys to those representing workers employed by subcontractors represented in both the past and current projects (loss of 273 surveys) for a total of 80 subcontractors. We thus analyzed 1279 surveys (532 baseline surveys and 747 current surveys; 215 workers completed surveys for both past and current projects) that reflected workers' reports on the safety climate of the same group of subcontractors when working under a past general contractor versus a current exemplary general contractor.

We examined the characteristics of the total group and by survey time point ("baseline" referring to a past general contractor and "current" collected after 30 days with a current exemplary contractor). We used hierarchical linear models (HLMs) to examine the relationship of general contractor safety climate scores between the past and the current project. This model used random intercepts to account for correlated responses of individual workers nested within subcontractor. Secondary analyses examined the same models for four other safety outcomes (subcontractor safety climate, co-worker safety attitudes, individual safety behaviors, and crew safety behaviors). We repeated these analyses among large, medium, and small sized subcontractors to examine the effects of safety flow-down on small and medium-sized contractors and to evaluate variation in safety climate by subcontractor size. These models included subcontractor size in addition to project status (past/current), as well as the interaction of subcontractor size and project to assess whether the relationship between safety climate and project status varied by subcontractor size. In a similar fashion, we examined the relationship of the size of the general contractor and safety climate between those general contractors of past projects to those of current projects. This model includes an interaction for general contractor size and general contractor project.

Finally, we evaluated the relationship between the current general contractor safety climate score to the changes made by subcontractors to meet the general contractor project safety requirements. We used an HLM comparing the general contractor safety climate score and the number of safety item changes made by each subcontractor. Similar to our previous analyses (Dale et al., 2020), we included random intercepts for subcontractor and individual worker in the model. We also described changes in specific safety items by the size of the subcontractors and the total number of safety requirements of each general contractor.

All analyses were conducted using R version 3.6.0, with packages "dplyr", "sqldf", "lme4", "lmerTest" and "lsmeans" utilized for data management and analysis (Bates et al., 2015;

Grothendieck, 2017; Kuznetsova et al., 2017; Lenth, 2016; R Core Team, 2019; Wickham et al., 2019).

4. Results

We collected 1279 surveys from workers employed by subcontractors on projects with 139 different general contractors on past projects and six general contractors on their current projects. 74% of workers completed their baseline survey within a month of working on their past project. These workers were employed by 80 different subcontractors, with 10 of the subcontractors working on more than one of the current general contractor projects (total of 91 subcontractor- general contractor combinations). The workers were predominately male, Caucasian, and employed in a variety of trades. The only statistically meaningful difference between the workers on past and current projects was in the distribution of trades (Chi-square test, P=0.02) (see Table 1).

We compared workers' perceptions of safety climate and behaviors between their past project and their current project with an exemplary general contractor. We first examined the group of all subcontractors and found that the worker-perceived general contractor safety climate was markedly better on the current project than on the past project (Table 2). Safety flow-down effects were large with significant changes in scores for subcontractor safety climate, co-worker safety attitudes, and crew safety behaviors comparing the past project to the current. Only self-reported individual behavior did not change.

Next, we examined whether these effects of safety flow-down from general contractors on past and current projects differed by the size of the subcontractors (Table 2). Higher safety scores indicated better measures of safety. While the relationship between project and safety climate scores did not vary by subcontractor size (interaction P values=0.07–0.82), most measures of safety climate and behaviors were highest among large subcontractors and lowest among small subcontractors, both for the past and current projects. Differences in general contractor mean safety climate scores between past and current projects were seen among both large and medium subcontractors with no difference among small. Among the secondary safety outcomes, subcontractor and coworker safety climate scores between past and current projects showed large and significant differences in scores of medium-sized subcontractors, but not among large or small subcontractors.

Next we examined whether the size of the *general contractor* affected the flow-down of safety to subcontractors to test the hypothesis that small and medium sized subcontractors would improve their safety climate and the safety behaviors of their workers when working on the projects of general contractors with exemplary safety programs. In HLM models accounting for different sized general contractors (large versus small), we found significant differences in mean scores of worker-perceived general contractor safety climate among those working under large general contractors but not under small general contractors, shown in Table 3. There were significant differences in the perception of safety climate between workers employed by current versus past large-sized general contractors for all other safety outcomes except crew safety, with better safety reported from those employed on projects with the current exemplary general contractor. There was no difference in safety climate perceptions when working under small-sized general contractors for any condition. The interaction P values for past/current project and general contractor size were statistically significant for general contractor safety and coworker safety ($P<0.0001$ and $P=0.001$, respectively), indicating that the effect of past vs. current project on these safety scores varied by general contractor size.

We repeated the analyses presented in Tables 2 and 3 restricted to the subset of workers (n=197) with completed surveys from the past and current project and showed substantially similar results (data not shown). These results did not support our hypothesis that small contractors would improve their safety climate and safety behaviors when working under general contractors with exemplary programs.

We then explored the content of the current general contractor's safety programs. The safety management programs included the written policies or rules and procedures required and workers compliance to those policies. We examined the number of changes in safety policies required from the subcontractors employed on the general contractor projects. We identified 18 safety expectations the general contractors required of the subcontractors, described in four categories: selected safety policies (related to specific tasks), documentation of safety, personal protective equipment (PPE) policies, and participation in project meetings. All of these safety policies exceeded federal regulations. Each general contractor required between eight and 17 of the 18 safety policies identified in this study, with large-sized general contractors requiring more policies (13 to 17) compared to smaller general contractors (8 to 12). Table 4 shows the safety policies required by each of the general contractors, the number of subcontractors contracted to work on their projects, and the number of these subcontractors that lacked each policy, and therefore, were required to make a change in their safety program to meet the general contractors' expectations. Subcontractor participation in project meetings (3 activities) was a condition of employment and not expected to become part of the written subcontractor safety program so these activities were excluded from the list of policies lacking in the subcontractors' safety programs. Some policies such as 100% 6-foot tie-off policy were required by all six general contractors and were already a part of many subcontractors' safety programs, so few subcontractors were required to make this change to their safety programs. Other requirements such as 100% tie-off in scissor lift policy were lacking, so resulted in more changes to the subcontractor safety program. Safety policies that were required by only a few general contractors were not a part of many subcontractor's safety programs, so most or all of these subcontractors were required to make changes (i.e., using ladders last, store materials off the ground). Personal protective equipment (PPE) policies were common in safety programs although more small subcontractors lacked PPE policies. Similarly, documentation requirements were more often new processes for small subcontractors compared to medium or large sized subcontractors. In general, safety policies that were required by more general contractors were already a part of many subcontractor's safety programs.

There was a significant correlation between the number of safety policies required to be changed by subcontractors on current projects (i.e. policies lacking) and their workers' perception of the general contractor's safety climate (Spearman correlation $r=0.36$; $p=0.0009$). An HLM assessing the association between the number of subcontractor safety policy changes required on projects to the outcome of worker-perceived general contractor safety climate also showed a significant relationship (beta 1.59; p=0.003), with a 1.6 point improvement in the general contractor safety climate score for each 1 additional safety policy change made by the subcontractor (a change of 6 safety policies was associated with a nearly 10 point change in the perception of safety climate of the general contractor). These results showed that general contractors' expectations of their subcontractors' safety activities influenced the adoption of safety practices into the subcontractors' safety programs. All of the general contractor required safety policies exceeded federal regulations by OSHA, yet participating subcontractors were required to follow them as a condition of employment.

5. Discussion

This study tested the hypothesis that small and medium sized subcontractors would improve their safety climate and the safety behaviors of their workers when working on the projects of general contractors with exemplary safety programs. Our results supported this hypothesis, as workers reported higher general contractor safety climate scores when working under general contractors with exemplary programs compared to other general contractors, but this improvement did not vary by size of the subcontractor. There were similar improvements in the other safety metrics of the subcontractor's workers when working on projects of general contractors with exemplary safety programs, suggesting the flow-down of safety is perceived at all levels of the project organization (subcontractor, coworker, crew, individual). There was also greater perceived safety when working on projects of larger general contractors, whose safety programs were more robust than smaller general contractors. Within construction projects, the safety climate perceived at the general contractor level, flows down to safety across all levels of the project.

We also examined whether general contractors' expectations of their subcontractors' safety policies influenced the adoption of safety policies into the subcontractors' safety programs. Subcontractors of all sizes had to make changes to meet general contractor's expectations but smaller sized subcontractors needed to make more safety program changes to be in compliance on projects. Unlike large subcontractors, small subcontractors were required to make safety policy changes related to documentation and PPE. All of the general contractors required some policies that exceeded OSHA regulations such as 100% tie off at 6', 100% hard hat, glasses, and boots, written safety programs and weekly toolbox talks. The majority of the subcontractors had these safety policies as part of their regular safety programs, suggesting that subcontractors in the local region had previously adopted these local general contractor safety policies, as another example of flow down of safety. Other safety policies such as stretch and flex and use ladders last programs were less common among the general contractors and were not a part of most of the subcontractors' safety programs. For companies that are striving to improve their safety climate, our findings found a positive relationship between the number of safety policies imposed by general contractors to higher safety climate scores perceived by workers. This suggests that more robust safety programs with safety policies exceeding OSHA regulations can improve the safety climate on the project. The flow-down of safety from general contractors with exemplary safety programs is perceived by workers and the safety policies may become adopted by subcontractors overtime.

While these data show safety flow-down from general contractors to their subcontractors, they do not describe the mechanism by which this influence occurs. There are several direct and indirect ways that construction contractors may gain ideas or initiatives to consider for their safety programs. Multiple intermediaries communicate new ideas for safety from several parts of the complex construction employment system (Slaughter, 2000). In construction, intermediaries may share valuable ideas for safety, although the adoption of the idea or innovation may depend on the culture of the company, the impact of the innovation on the organization, and the net gain from using the innovation (Slaughter, 2000). Industry relationships have been shown as a means to influence implementation of construction innovations (Blayse, 2004). On large projects, general contractors influence the safety programs of subcontractors via contractual requirements but may also influence subcontractors by modeling successful safety programs and by exposing them to new safety practices and equipment. It is likely that several factors drive the observed safety “flow-down” resulting in subcontractors’ adoption and integration of new safety practices into their safety management programs.

Strengths of the study include the use of leading indicators of safety (safety climate and behaviors) rather than lagging indicators such as recorded injuries, and the observation of change in these indicators over time. Few studies have gathered information using leading indicators across the many organizational levels present on construction projects, including the general contractor, subcontractor, and worker. Our study was able to study a large population of construction workers as they changed projects and general contractors, allowing us to measure change at the level of the general contractor, subcontractor, and worker. While evaluation of one large owner-run construction project showed that a clearly defined safety program communicated consistently throughout the project influenced worker behaviors (McDonald et al., 2009), existing studies are primarily cross sectional; few prospective studies have examined changes over time in the safety behaviors of subcontractors and their workers in response to the safety culture and flow down requirements of their general contractors. Moreover, measurement issues hinder evaluations of the effectiveness of occupational health and safety programs, which are generally gauged by the incidence of injuries and lost time. These lagging indicators of safety are insensitive to change, do not provide timely information, and do not measure barriers to change or actions taken to address workplace hazards (Grabowski et al., 2007; Hinze et al., 2013b; Trethewy, 2003). Leading indicators such as safety behavior provide more timely and relevant safety information, and have been linked to injury prevention. (Choudhry et al., 2009; Institute for Work and Health, 2011; Laitinen et al., 1999; Mikkelsen et al., 2010; Toellner, 2001).

This study also has several limitations. Workers may have had differential recall of safety climate and behaviors on their past project versus their current project. This possible effect is lessened by the short interval between the past and current job (one month or less among 74% of respondents). Because of the complex dynamics and rapidly changing workforce of construction sites, it is difficult to obtain longitudinal surveys from workers (Sparer et al., 2013). We were able to obtain surveys at only one time point from many workers. As described above, analysis of changes over time among those workers with data at two time points showed similar results to those of the surveyed workers as a whole. We did not have ratings of safety programs for the 139 general contractors represented by past projects. Some of these past general contractors were also likely to have exemplary safety practices, which may have reduced the observed differences between current general contractor and past general contractor projects, reducing the observed effects of safety flow-down. While we know which policies subcontractors were required to change, we have no measures of how fully the subcontractor's implemented the general contractor requirements. Under-implementation would also bias our study results toward no observed differences in climate and behaviors. Finally, there were differences in the construction trades represented by workers caputured at baseline and at 30 day onsite follow-up; such differences could have contributed to over or under estimation of the differences between past and current project.

5.1 Study implications and practical contributions

This study showed that safety from the general contractor flows down to influence the safety of subcontractors both directly by project-level safety requirements and indirectly by modelling strong safety programs that create a better safety climate. The flow down occurs over time with subcontractors adopting safety practices that are required by more general contractors or by working on multiple projects for the same general contractor. Importantly, the influence and adoption of improved safety practices applies to smaller subcontractors, although general contractors may need to assist smaller subcontractors to meet the higher safety expectations. All of the general contractors with exemplary programs included safety expectations that exceeded OSHA requirements that workers on their projects perceived as creating a stronger safety climate. General contractors can serve as effective intermediaries to improve subcontractor's safety programs, including smaller subcontractors, by consistently requiring clear safety expectations to all subcontractors employed on their projects overtime.

6. Conclusions

The construction industry continues to suffer from high rates of fatalities and injuries despite the availability of guidance documents and regulations on how to create robust, effective safety management programs. Small sized firms lack the resources to develop quality safety programs but may benefit from working under general contractors with exemplary safety programs. The purpose of this study was to examine the flow-down influence of general contractors' safety programs on the safety climate and safety behaviors among workers employed by small and medium sized subcontractors. We surveyed workers employed on construction projects of six general contractors who have an OSHA designation of an exemplary safety program. Workers reported the safety climate of the general contractor from their most recent past project and the general contractor with an exemplary safety program on their current project. Workers also reported the safety climate of their subcontractor and safety behaviors of their coworkers. We also explored the changes in safety policies and practices of the subcontractors required by the general contractors to work on the project. We examined if there were differences in safety measures and safety elements of subcontractors based on the size of the firm. Results showed workers perceived general contractors with exemplary safety programs had stronger safety climates than other general contractors. Smaller subcontractors had less robust safety programs with fewer safety elements than larger subcontractors, and smaller subcontractors had to adopt more safety policies and practices to work for general contractors than large subcontractors. Although smaller subcontractors made changes to their safety programs, supporting our hypothesis that safety flows down from general contractors, it is not known if these changes will be incorporated into the subcontractor safety program. The key findings are confirmation that smaller subcontractors have less robust safety programs than larger subcontractors, and that general contractors are effective intermediaries to improve the safety programs of smaller subcontractors. This study contributes to our understanding that intermediaries can influence development of the safety programs of small sized firms, particularly when the firms perform subcontract work under employers with exemplary safety programs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

The authors would like to acknowledge the General Contractors, Subcontractors, and all of the construction workers who participated in this research study. Without their participation, this study would not have been possible. We would also like to thank Anna M. Kinghorn and Alexandra O'Brien from the Washington University in St. Louis Occupational Safety and Health Research Lab for their contributions to data collection, transcription, and assistance with manuscript preparation.

Funding:

This work was supported by CPWR: The Center for Constructions Research and Training (CPWR) [Cooperative Agreement Number U60-OH009762], funded by the Centers for Disease Control and Prevention/NIOSH and the Washington University Institute of Clinical and Translational Sciences [Grant UL1TR002345] from the National Center for Advancing Translational Sciences (NCATS) of the National Institutes of Health (NIH). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CPWR, the Centers for Disease Control and Prevention/NIOSH, the Department of Health and Human Services, or the National Institutes of Health. These funding bodies had no role in the design of the study and collection, analysis or interpretation of data, or in writing the manuscript.

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Research Highlights:

- Safety in construction is complex and challenging to control accident risks.
- Safety management programs reduce risk of accidents and injuries.
- Workers perceive strong safety climates of contractors with strong programs.
- Large contractors adopt safety practices of exemplary general contractors.
- Small contractors adopt fewer safety practices than large contractors.

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Table 1.

Participant characteristics by time point

	Overall	Survey at baseline	Survey after 30 days on project
Surveys, n	1279	532	747
Participants, n	1064	528	740
Subcontractors, n	80	80	80
General contractors, n	145	139	6
Male Gender, n (%)	1254 (98.3)	523 (98.5)	731 (98.1)
Age, mean ± SD	38.97 ± 10.65	38.31 ± 10.42	39.45 ± 10.80
Race, n (%)			
White	1109 (87.8)	468 (89.0)	641 (87.0)
Black/African American	73 (5.8)	26 (4.9)	47 (6.4)
Hispanic/Latino	62 (4.9)	24 (4.6)	38 (5.2)
Asian/Asian American	3 (0.2)	1 (0.2)	2 (0.3)
Other	16 (1.3)	7 (1.3)	9 (1.2)
Trade, n (%)			
Carpentry	219 (17.1)	104 (19.5)	115 (15.4)
Drywall	73 (5.7)	31 (5.8)	42 (5.6)
Electrical	206 (16.1)	66 (12.4)	140 (18.7)
Iron	120 (9.4)	60 (11.3)	60 (8.0)
Pipefitter	106 (8.3)	40 (7.5)	66 (8.8)
Sheetmetal	89 (7.0)	34 (6.4)	55 (7.4)
Other[†]	466 (36.4)	197 (37.0)	269 (36.0)

[†]includes trades Brick/masonry, Cement, Communications, Flooring, Paint, Plumbing, Taper, Roofing, Sprinkler, Elevator, Glazier, Insulation, Operator, Waterproofing, General Labor

Table 2.

Safety climate measures by current general contractor and past general contractor projects, stratified by subcontractor size

		Surveys	Current Project	Past Project	
Subcontractor group	Outcomes	n	mean (CI)*	mean (CI)*	P*
All Subcontractors‡	General Contractor Safety	1261	74.9 (72.9–76.8)	70.1 (68.0–72.3)	<0.0001
	Subcontractor Safety	1249	82.0 (80.5–83.5)	79.4 (77.7–81.1)	0.003
	Coworker Safety	1249	81.1 (79.6–82.6)	78.8 (77.2–80.5)	0.008
	Self Safety	1244	82.3 (81.0–83.5)	81.8 (80.4–83.2)	0.49
	Crew Safety	1244	83.8 (82.4–85.2)	82.1 (80.6–83.6)	0.02
Large Subcontractors‡	General Contractor Safety	382	76.8 (70.9–82.7)	69.8 (63.4–76.1)	0.0004
	Subcontractor Safety	378	83.4 (79–87.7)	81.7 (76.9–86.4)	0.31
	Coworker Safety	382	82.7 (78.4–87)	81.2 (76.5–85.8)	0.34
	Self Safety	378	83.5 (79.7–87.2)	82.5 (78.4–86.5)	0.48
	Crew Safety	377	84.6 (80.4–88.8)	82.6 (78–87.1)	0.14
Medium Subcontractors‡	General Contractor Safety	592	73.4 (69.3–77.6)	68.8 (64.3–73.3)	0.003
	Subcontractor Safety	588	81.9 (78.8–5.0)	77.3 (73.9–80.7)	0.0003
	Coworker Safety	584	80.6 (77.6–83.6)	76.7 (73.3–80.0)	0.002
	Self Safety	587	82.2 (79.6–84.9)	81.3 (78.4–84.3)	0.41
	Crew Safety	587	83.5 (80.5–86.4)	81.6 (78.4–84.8)	0.07
Small Subcontractors‡	General Contractor Safety	287	74.9 (69.9–79.9)	72.8 (67.4–78.2)	0.34
	Subcontractor Safety	283	80.9 (76.9–84.8)	81.3 (76.9–85.7)	0.82
	Coworker Safety	283	80.4 (76.5–84.3)	80.6 (76.3–84.8)	0.92
	Self Safety	279	81.2 (77.7–84.7)	82.0 (78.2–85.8)	0.59
	Crew Safety	280	83.5 (79.8–87.2)	82.6 (78.6–86.6)	0.54

*Means, confidence intervals and P values derived from hierarchical linear models, where safety score is the outcome, project (current versus past), subcontractor size, and interaction of project by subcontractor size are the independent variables (fixed effects).

Interaction P values ranged from 0.07 to 0.82 across the five safety scores, indicating that the relationship between project and safety score did not vary by subcontractor size for any of the five scores

‡There were a total of 80 subcontractors (large: n=14, medium: n=32, small: n=34)

Random intercepts for subcontractor and participant nested within subcontractor included to account for within group clustering. Note that the general contractor by subcontractor size interaction was not significant for these models, meaning that subcontractor size is not an effect modifier of the general contractor safety climate to subcontractor relationship.

Table 3.

Safety climate measures by current versus past general contractor project, stratified by general contractor size

	Outcomes	Surveys n	Current Project mean (CI)*	Past Project‡ mean (CI)*	P*
Large General Contractor	n		3	5	
	General Contractor Safety	586	77.8 (74.2–81.4)	64.9 (59.1–70.7)	<0.0001
	Subcontractor Safety	583	83.0 (80.4–85.6)	79.3 (74.6–84.0)	0.04
	Coworker Safety	580	82.8 (80.3–85.4)	76.6 (71.9–81.2)	0.0005
	Self Safety	575	82.7 (80.5–84.9)	79.4 (75.4–83.4)	0.03
	Crew Safety	575	84.8 (82.4–87.1)	82.0 (78.0–86.1)	0.07
Small General Contractor	n		3	22	
	General Contractor Safety	524	69.8 (65.6–74.0)	70.5 (66.7–74.3)	0.68
	Subcontractor Safety	520	80.4 (77.2–83.5)	79.3 (76.3–82.2)	0.43
	Coworker Safety	517	78.3 (75.3–81.4)	79.6 (76.7–82.5)	0.37
	Self Safety	519	81.6 (78.9–84.4)	81.8 (79.3–84.3)	0.92
	Crew Safety	519	82.0 (79.2–84.9)	81.1 (78.5–83.7)	0.42

*Means, confidence intervals and P values derived from hierarchical linear models, where safety score is the outcome variable, project (current versus past), general contractor size and interaction of project by general contractor size are the independent variables (fixed effects).

Interaction P values for general contractor safety (P<0.0001) and coworker safety (P=0.001) indicate the relationship between project and these safety scores vary by general contractor size. Interaction P values for other safety scores (0.09 to 0.38) were not significant.

‡155 surveys in past project not included, due to general contractor size not obtained

Random intercepts for subcontractor and participant nested within subcontractor included to account for within group clustering

Table 4.

General contractor required safety policies and subcontractors lacking required safety policies

Category	Safety policy #	GC with policy, N	SCs on projects with policies, N	SCs lacking Policies, N	Proportion of subcontractors by size lacking the policy: Total (%)	Small* (%)	Medium* (%)	Large* (%)
Safety Specific Policy	100% 6' tie off policy, all trades	6	91	0	0.0	0.0	0.0	0.0
	100% Tie off scissor lift policy	5	79	74	93.7	92.3	100.0	83.3
	Daily Mandatory Stretch and Flex	2	36	34	94.4	90.9	100.0	88.9
	Use ladders as the last option	1	17	17	100.0	100.0	100.0	100.0
	All materials stored off ground	1	17	17	100.0	100.0	100.0	100.0
Documentation	Written safety program	6	91	4	4.4	9.1	0.0	5.0
	Weekly contractor Toolbox Talk	6	91	16	17.6	24.2	15.8	10.0
	Equipment inspection checklist	5	79	21	26.6	53.8	11.4	16.7
	Daily Pre-Task Plan Document	4	63	24	38.1	72.2	36.7	0.0
PPE Policy	100% Hard Hat	6	91	3	3.3	6.1	0.0	5.0
	100% Glasses	6	91	1	1.1	3.0	0.0	0.0
	100% Boots	6	91	3	3.3	6.1	0.0	5.0
	100% High Viz	5	79	2	2.5	3.8	0.0	5.6
	100% Gloves	2	36	24	66.7	90.9	62.5	44.4
	Double eye protection$	1	14	11	78.6	66.7	85.7	75.0

GC=general contractor; SC= subcontractor; PPE= personal protective equipment;

#Safety policies are defined as rules and procedures required by the general contractor.

*Subcontractor by size: small (n= 33), medium (n= 38), large (n= 20); note the number of subcontractors by size for each policy was dependent on the number of subcontractors employed on general contractor projects that required the policy.

$Double eye protection was only required for selected tasks/tool use that risked causing particles in the eyes (welding, cutting, grinding) so eliminated painters and electricians (3 subcontractors)