

A Model of Communicative and Hierarchical Foundations of High Reliability Organizing in Wildland Firefighting Teams

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Abstract

Organizational hierarchy is an inescapable aspect of many exemplary high reliability organizations (HROs). As organizations begin to adopt HRO theorizing to improve practice, it is increasingly important to explain how HRO principles—which assume the hallmarks of a flat hierarchy—can be understood and enacted in rigidly stratified organizations. We propose a preliminary theoretical model suggesting how various supervisor–subordinate and work group communication patterns and practices enable members to navigate hierarchy to achieve high reliability. We test the model using structural equation modeling on a sample of $N = 574$ U.S. wildland firefighters from three federal agencies. Results suggest how organizational members might overcome common hierarchy-based constraints to HRO through considering how leaders throughout a chain of command communicate to cultivate the necessary cross-level awareness of an operation, and ways in which supervisors, members, and groups might cultivate interactional cultures with respectful affect.

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High reliability organizations (HROs) operate for long periods of time while experiencing fewer catastrophic accidents than would be expected given the risks inherent to their environments, processes, and/or technologies (Rochlin, 1993). Example HROs include wildland firefighting, surgical teams, nuclear power plants, and airline flight crews, among others. Initial definitions of what comprised an HRO explicitly acknowledged organizational hierarchy, with theorists such as Roberts and Rousseau (1989) considering *extreme hierarchic differentiation* a defining feature of these organizations (see also Baker, Day, & Salas, 2006; LaPorte, 1996; LaPorte & Consolini, 1991). However, as theorizing about high reliability organizing *as a process* has evolved (see Weick & Sutcliffe, 2001, 2007, 2015), the notion of hierarchy has mostly disappeared from theoretical models. There are good reasons for this, namely, that describing HRO as an emergent process is ontologically incompatible with a focus on the existence (and possible determinism) of a priori organizational structures. As organizations begin to adopt recommendations based on HRO theorizing (see Lekka & Sugden, 2011; Vogus & Sutcliffe, 2007; Vogus & Welbourne, 2003 and others), it is increasingly important to explain how principles and practices of HRO, which assume the communicative hallmarks of a flat hierarchy, can be understood and enacted in organizations that are inescapably stratified (e.g., wildland firefighting, aircraft carriers, and hospital emergency rooms). Indeed, several studies show that important hindrances to high reliability organizing often are related to hierarchy, particularly supervisor–subordinate communication, and barriers to communication stemming from a lack of positional authority to voice concerns and objections (Barton & Sutcliffe, 2009; Brueller & Carmeli, 2011; Nembhard & Edmondson, 2006).

The purpose of this study is to show that, while organizational members might not be able to flatten the hierarchy in which they work, they might communicate in various ways to navigate hierarchy and overcome barriers to HRO. Navigating hierarchy means that supervisors, work groups, and members find ways to work around obstacles to communication imposed by stratified relationships. Navigating hierarchy involves considering ways that hierarchy is dynamic and enacted, rather than a rigid structure. This study reintegrates concerns about hierarchy into theorizing about HROs to derive a theoretical model of hierarchical high reliability communication. In particular, we propose that hierarchy enables and constrains high reliability organizing through particular leader and work group communication patterns and

practices. We test the model using structural equation modeling (SEM) on a random, stratified, representative sample of $N = 574$ U.S. wildland firefighters from three federal agencies. This study shows how high reliability organizing can be explained as communicative patterns and practices that direct member attention, guide inquiry and learning, and call on supervisors and teams to foster affective interactions that help members navigate a chain of command.

High Reliability Organizing

Current theorizing about high reliability organizing is dominated by a view that casts HRO as a process (see Weick & Sutcliffe, 2015). This perspective begins with the assumption that HRO environments are unpredictable and dynamic, and that action occurs in response to, and in anticipation of, the emergent environment as members directly experience it (Rochlin, 1993; Weick & Sutcliffe, 2015). The most widely known HRO model is Weick and Sutcliffe's (2001, 2007, 2015) five principles, which encompass sets of behaviors they have observed contributing to high reliability in a range of hazardous organizations. *Preoccupation with failure* refers to members' efforts to identify what "failure" looks like by learning as much as possible from both small accidents and catastrophes, to articulate how an emerging situation is unfolding, and to report mistakes or deviations from intended plans. *Sensitivity to operations* refers to sharing frontline information to build a broad, collective picture of organizational goals and taking deliberate steps to maintain ongoing awareness of activities and potential problems. *Reluctance to simplify interpretations* means that members resist the temptation to jump to conclusions. Instead, they seek out and retain alternative perspectives of the emerging situation, and strive to attain more nuanced understandings about their environments, potential work trajectory, and possible system responses to interventions. *Commitment to resilience* refers to enhancing individual, team, and organizational abilities to bounce back from mistakes; cross-training members to enhance their repertoires of understanding and action; and proactively applying insights and lessons from past performances (including mistakes) to current and future operations. Finally, *deference to expertise* refers to an organization's efforts to migrate decision and action authority to those who are most knowledgeable at that moment about an issue or problem, regardless of rank.

As theorized, Weick and Sutcliffe's *principles* describe ongoing individual and coordinated actions by which members maintain awareness of complex and changing circumstances. Central to the principles is the notion of *requisite variety*, which means that environments with a great deal of

complexity need organizational members to respond with equal or greater complexity through their actions (Ashby, 1962; Weick, 1987). Requisite variety is achieved through inviting and incorporating multiple and divergent perspectives, which is reflected in each of the HRO principles. The lynchpin for high reliability organizing is the ability of group members to incorporate key information, concerns, and insights about their environments into their group decision making and learning processes. Therefore, we argue that high reliability organizing depends on communication patterns and practices by which teams enable members to convey information to those best equipped to make decisions, and incorporate lessons from mistakes and failures into ongoing activities. We propose that to better understand how team members navigate organizational hierarchies in HROs, it is necessary to move toward theorizing relationships among the HRO principles, hierarchical realities such as supervisor and team communication, and learning activities.

High Reliability Organizing and Hierarchy

To date, few studies directly examine how hierarchy can serve the goals of HRO processes. One notable exception is Bigley and Roberts (2001), who examined how the incident command system (ICS)—a bureaucratic arrangement used by the U.S. Federal Emergency Management Agency, wildland fire, and other emergency responders—provides a scalable hierarchical structure that enables organizational flexibility for emergency response. They found that the ICS platform allows an organization to configure management structures that are as big or as small as necessary depending on incident demands. The consistency of designated roles enables responders to confidently switch among roles as the incident size and ICS configurations change. Emerging conditions are dynamic, requiring members to improvise in response to changing conditions. However, improvisation is only possible when, as Bigley and Roberts (2001) note “. . . supervisors permit and direct authority migration” (p. 1288), which results in *deference to expertise*. However, a crucial drawback of hierarchies is that the nature of their stratified relationships can become members’ central concern in their interactions. In particular, it can be difficult for subordinates to share partial information and tentative conclusions, which are the types of information HROs depend on to catch problems while they are still small and manageable. To address communication constraints within hierarchies, the next section presents various findings illustrating how supervisor communication and action affect team practices and interpersonal climate in HRO contexts.

Supervisor Inclusive Communication

An organization's hierarchy becomes evident, perhaps most notably, in the relationship between supervisor and subordinate, in particular, the tone or conditions for communication established by the supervisor. When serving in hierarchical roles, members might become focused on what they can (and cannot) say to whom and how they should say it, rather than openly expressing concerns about circumstances they face (Barton & Sutcliffe, 2009; Blatt, Christianson, Sutcliffe, & Rosenthal, 2006; Detert & Burris, 2007). In particular, the notion of supervisor inclusive communication refers to the powerful impact a supervisor has on generating an affective climate that fosters or impairs communication activities essential for HRO, including voicing behaviors, error reporting, and learning (Brueller & Carmeli, 2011; Edmondson, 1999; Nembhard & Edmondson, 2006). Supervisor inclusive communication refers to ways supervisors communicate with subordinates to both solicit input, and encourage subordinates to express alternative viewpoints (Nembhard & Edmondson, 2006). When supervisors use an inclusive communication approach, they model openness and nondefensiveness, and can foster an affective climate conducive for information sharing. These inclusive communication efforts contribute to condoning and providing time for reflective learning both in the moment and after-action—activities that are not likely without supervisory approval and engagement.

Research in HRO contexts often links supervisor communication with employee voice, and psychological safety—two major constructs that address hierarchical traps. Employee voice refers to members' efforts to contribute information and recommendations to benefit the organization (Morrison, 2011). For instance, Barton and Sutcliffe (2009) found that when wildland firefighters voiced concerns, they often interrupted problematic "trajectories of action," which provided opportunities to pause for reflection and sense-making. However, although voicing concerns is crucial for avoiding problems, research reveals that several social factors influence voice. In particular, supervisor behaviors to invite or discourage voice have a powerful impact on members' voicing behaviors in a team, as supervisors set the tone for team interactions (Baker et al., 2006; Barton & Sutcliffe, 2009; Blatt et al., 2006; Detert & Burris, 2007; Knox & Simpson, 2004). Institutional and self-imposed pressures to finish a job can also keep members quiet (Barton & Sutcliffe, 2009). A second construct, psychological safety, refers to members' perceptions that their work group is a safe place to take interpersonal risks (Edmondson, 1999). A group's ability to communicate openly with each other—to voice concerns, raise questions, or provide input—largely hinges on supervisors' efforts to minimize their positional power and status to foster

candid communication (Bunderson & Reagans, 2011; Detert & Edmondson, 2011). Other studies found that when discussing failures, work group supervisors play a key role in influencing the interpersonal culture of the group because subordinates look to their immediate superiors for behavioral cues (Brueller & Carmeli, 2011). Furthermore, disclosing potentially sensitive information (e.g., reporting one's errors) depends on employees' trust in their managers and colleagues (Vogus & Sutcliffe, 2007). To complicate matters, a defining aspect of HROs is that particularly dangerous situations often move at a fast tempo, which might limit opportunities for inclusive communication when teams are responding quickly to changing circumstances (Rochlin, 1993). However, we expect that supervisors set the tone for their team's interactions. As such, supervisors play an important role in ensuring their team maintains practices that foster inclusive communication, whether operating at a slower preparatory tempo or a faster operational pace.

Cross-Level Facilitation

Hierarchy also affects high reliability in whether or how it isolates or connects disparate parts of the organization, especially when operations are decentralized (LaPorte & Consolini, 1991). Cross-level facilitation helps build big picture understandings of an operation or event, what Roberts (1993) referred to as "having the bubble." By attending to cross-level facilitation, leaders at each level ensure that big picture awareness of conditions across an incident is shared down the chain of command, and that frontline awareness is shared upward. This representation of the operation built through efforts to foster cross-level awareness includes members' understandings of their overall activity system, including their place in that system, the environment they are responding to, and projections of how that environment might change in the near future (Bigley & Roberts, 2001). Indeed, Connaughton, Shuffler, and Goodwin (2011) found that, as military operational strategies move toward more dispersed work, teams must increasingly rely on collaboration and negotiation among lateral leaders, and between leaders and followers, rather than relying on direct oversight. Therefore, a key requirement of HROs is the ability of members to cultivate a shared cross-level awareness of the whole operation, and an understanding of how each semiautonomous unit contributes to it. In a hierarchy, leaders at each level control the communication between units and levels, and within each unit. When leaders (direct supervisors and/or more distant decision makers) attend to cross-level concerns, they give subordinate members the freedom to pay attention to and share subtleties and changes in their immediate surroundings.

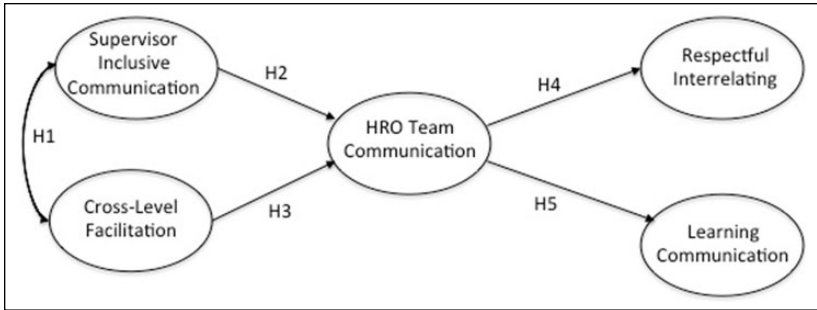


Figure 1. Hypothesized model of high reliability communication in a hierarchy.
Note. HRO = high reliability organization.

Supervisor inclusive communication and cross-level facilitation are likely related to each other, even though they address different sets of activities. Therefore, we propose the first hypothesis (see Figure 1):

Hypothesis 1 (H1): Supervisor inclusive communication and cross-level facilitation will covary.

To summarize, supervisor inclusive communication and cross-level facilitation are important for enabling high reliability organizing because these activities, focused on cultivating candid and respectful communication between higher and lower ranking members, can help to overcome common hierarchy-related barriers to voice (see Barton & Sutcliffe, 2009; Blatt et al., 2006). It also is important to consider how team communication patterns and practices are implicated in ways that members navigate hierarchy in HROs.

High Reliability Through Team Communication Patterns and Practices

Extensive research has shown how teams are a confluence of organizational and professional expectations that get interpreted into action through team communication patterns and practices (Myers & McPhee, 2006; Seibold, 1998). That is, work group practices groom members to see themselves and their work in relation to local values, and to act and interact according to these local norms (Barker, 1993; Jahn, 2016; Myers, 2005; Myers & McPhee, 2006). HRO research has increasingly attended to work group activities, noting how members hold themselves accountable to their fellow work group members, and subordinate their actions to the broader goals of the group

(Baker et al., 2006; Jahn, 2016; Myers, 2005; Myers & McPhee, 2006; Novak & Sellnow, 2009; Vogus & Sutcliffe, 2007). Hence, work group communication patterns and practices are crucial sites of activity in which members engage in the proactive coordination, ongoing information exchange, and learning interactions that characterize the five HRO principles. This section addresses HRO team communication, respectful interrelating, and learning communication processes.

HRO Team Communication

HROs must cultivate communication that fosters local sharing, learning, and sensemaking. Vogus and Sutcliffe (2007) proposed that we will observe evidence of high reliability organizing through assessing how members of teams communicate with each other. They operationalized the five HRO principles almost entirely as team communicative patterns. Vogus and Sutcliffe's (2007) scale items address how members of a (nursing) team communicate to gain understandings of each others' competencies, co-construct a vision of how they want a situation to progress, voice anticipated problems, and take ownership of their competencies while trusting those of fellow members. This team-level scale assessing the communication behaviors that evince the HRO principles is referred to by Vogus and Sutcliffe (2007) as the *safety organizing scale*; for clarity in this study, we refer to the scale as HRO team communication.

Supervisor inclusive communication and cross-level facilitation capture communication as hierarchically embedded functions, while HRO team communication focuses on within-group sharing. We propose the following hypotheses (see Figure 1):

Hypothesis 2 (H2): Supervisor inclusive communication positively predicts HRO team communication.

Hypothesis 3 (H3): Cross-level facilitation positively predicts HRO team communication.

Respectful Interrelating

The HRO principles explain how team members communicate with each other in the moment to co-construct their understanding of a situation through sharing and integrating their observations and insights into a collective awareness about nearby environments and activities (Weick & Sutcliffe, 2015). The HRO principles imply that members' enactment of them will involve respectful interactions. *Respectful interrelating* captures the mutual

trust, honesty, respect, and attention by which members coordinate information, insights, concerns, and action (Vogus, 2004). When members of a team engage in high-quality HRO team communication, they demonstrate high levels of trust, respect, honesty, and attention to each other; hence, we propose

Hypothesis 4 (H4): HRO team communication positively predicts members' respectful interrelating.

Learning Communication

HROs, in general, must glean as much knowledge as possible from both normal operations and unwanted outcomes, and pass these insights among its members (Roberts & Bea, 2001; Rochlin, 1993; Weick, 1987). Accordingly, HROs spend much energy and resources on understanding both problematic and successful activities to improve future operations. These lessons are shared immediately after incidents, and/or following daily work shifts through learning-based communication practices that often take place within teams. One such practice is an after action review (AAR). AARs are common in wildland firefighting and military operations. Members discuss their understanding of how events unfolded, activities that did and did not go as planned, and suggestions for improving operations in the future (Scott, Allen, Bonilla, Baran, & Murphy, 2013). Lessons emerging in learning-based communication activities can become part of the organization's body of knowledge, passed along through generations of members (Weick, 1987). We suggest that learning communication is likely when within-group communication patterns focus on concrete, operational details as evinced through HRO team communication behaviors; therefore

Hypothesis 5 (H5): HRO team communication will positively predict engagement in learning communication.

Method

Participants and Procedure

Wildland firefighting is one of the exemplary operations on which the HRO principles are based (Black & McBride, 2013; Weick & Sutcliffe, 2001, 2007, 2015). A random, stratified, and representative sample of 668 permanent seasonal and permanent full-time wildland firefighters was drawn from employee directories of federal land management agencies that contribute the

largest supply of wildland firefighters in the United States. After cleaning the data to remove all records with more than two missing values, the final data set contained $N = 574$ valid cases (86% of those surveyed), including 449 males and 125 females. The sample was drawn from three federal agencies, and included members from the U.S. Forest Service ($n = 231$), Bureau of Land Management ($n = 131$), and National Park Service ($n = 212$). The mean age of participants was 41.1 ($SD = 9.6$), with a mean of 15.9 years of experience in fire management ($SD = 9.2$). Participants represented all wildland fire functionalities, including strategy/oversight positions, namely, command and general staff such as fire management, duty officers, and incident command team members ($n = 147$); direct engagement and implementation positions, namely, on-the-ground firefighters ($n = 300$); and nonengagement support personnel including dispatchers, supply, and logistics personnel ($n = 127$).

A 15-minute telephone survey was administered by an independent polling organization. Members were drawn from a random, stratified, representative sample based on full-time agency affiliation and functional position during wildland fire incidents. U.S. wildland firefighting operations use the ICS, a scalable organizing structure that allows personnel from various agencies, organizations, and dispersed geographic areas to take on temporary roles in the command structure for the duration of individual fire events. Personnel may have no, minimal, or substantial history with others in the ICS structure associated with a given wildfire event. For instance, members of an incident command team often work together on multiple incidents throughout a season; however, on any given incident, the incident command team may be completely unfamiliar with the fire crews, dispatchers, and other support staff also assigned to the incident. For this study, we were interested in the role participants played in their *most recent fire event*; this role might have been either a temporary position within the ICS structure, or their full-time agency role. Therefore, each individual was asked to think back to his or her most recent fire event, and answer a series of Likert-type scale survey items with respect to the group or team he or she worked with most closely during that event. The majority of fire events on which members reported occurred within 3 months of the phone survey.

Preliminary Analyses

This study used a combination of established, modified, and newly formed measures. Because items comprising three of the five measures featured communication-based activities, we used a combination of exploratory and confirmatory methods to ensure differentiation among measures. The full sample ($N = 574$) was randomly divided into two subsamples for analysis.

One sample ($n = 250$) was used for exploratory factor analysis (EFA), following minimum sample size conventions for EFA (MacCallum, Widaman, Zhang, & Hong, 1999). The other slightly larger sample ($n = 324$) was used for confirmatory factor analysis (CFA), as this test requires a slightly larger sample size than EFA (Noar, 2003).

First, we conducted EFA on the smaller subsample ($n = 250$) using an orthogonal Varimax rotation to reduce 30 items into five factors. The EFA was constrained to five factors because we drew items from scales published in previous empirical studies (i.e., safety organizing scale, supervisor inclusivity, respectful interrelating, and learning communication), and were exploring whether a fifth construct, cross-level facilitation, was distinct from the other four. Hence, EFA was used to check whether items from the five constructs cross-loaded onto each other. After eliminating six items that cross-loaded onto two or more factors, all remaining items loaded onto their appropriate factor with loadings above .4. The final set of items is presented in Table 1. Next, a standard, correlated factors CFA was conducted on the larger subsample ($n = 324$) to verify the factor structure found in the EFA. A standard CFA model was specified such that indicators loaded onto only one factor and no error terms were correlated (Kline, 2011). Based on the EFA with orthogonal rotation, we suspected factors were distinct from, but likely related to, each other because they all contained items pertaining to HRO or communication behaviors; hence, we specified a correlated factors CFA model in which all latent variables were correlated (Noar, 2003). The CFA fit the data adequately, $\chi^2(220) = 304.01$, $p = .001$, comparative fit index (CFI) = .96, root mean square error of approximation (RMSEA) = .034, standardized root mean square residual (SRMR) = .046, explaining 99.9% of the variance. Although the chi-square test was significant, the other fit indices suggested strong fit. The means, standard deviations, and pairwise correlations of variables in the hypothesized model are presented in Table 2.

Measures

HRO team communication was measured using eight items from the *safety organizing scale*, which operationalized Weick and Sutcliffe's (2007) principles of high reliability organizing as a set of work group-level communication behaviors (Vogus & Sutcliffe, 2007). Items include "We discussed alternatives as to how to go about our work activities," and "We talked about mistakes and ways to learn from them" (1 = *strongly disagree* to 5 = *strongly agree*). The scale produced a unidimensional construct with acceptable factor loadings (.52-.69) and internal reliability (standardized Cronbach's $\alpha = .86$).

Table 1. Scale Items for the Variables in the Hypothesized Model.

Factor

Supervisor inclusive communication (adapted from Nemhard & Edmondson, 2006)

My boss actively sought input from a broad range of folks when making decisions.

My boss actively encouraged subordinates to question decisions that didn't make sense to them.

My boss encouraged people to bring up potential problems.

My boss listened to the less experienced members of my group when they brought up ideas or issues.

My boss actively listened when different views were presented.

Cross-level facilitation (adapted from Weick & Sutcliffe, 2007)

Leaders on this fire actively looked for problems.

There was always someone with authority to make decisions available and accessible in the event that something unexpected came up.

Leaders were constantly monitoring workload and span of control to reduce them when that became necessary.

Our superiors checked in with us frequently.

It was generally easy to obtain expert assistance when something came up that we didn't know how to handle.

HRO team communication (Vogus & Sutcliffe, 2007)

We talked about mistakes and ways to learn from them.

We discussed our unique skills with each other so we knew who on the fire had relevant specialized skills and knowledge.

We discussed alternatives as to how to go about our work activities.

We discussed what to look out for, when giving reports to new teams or units.

We took advantage of the unique skills of our colleagues, when attempting to resolve a problem.

We spent time identifying activities that we did not want to go wrong.

When errors did happen, we discussed how we could have prevented them.

Respectful interrelating (adapted from Vogus, 2004)

People showed a great deal of respect for each other.

The individuals I worked with were trustworthy.

We honestly reported what we perceived to each other.

Individuals paid attention to what others were doing.

Learning activities (adapted from Edmondson, 1999)

After the fire, we discussed what we learned.

After the fire, we discussed whether there were ways we could have predicted or prevented problems that arose.

Changes to procedures were recommended as a result of what we learned from our experiences on this incident.

Note. HRO = high reliability organization.

Table 2. Means, Standard Deviations, and Correlations of the Variables in the Hypothesized Model.

Variable	N	M	SD	α	1	2	3	4	5
1. Supervisor inclusive communication	574	4.06	0.70	.88	1.00				
2. Cross-level facilitation	574	4.18	0.62	.81	.53**	1.00			
3. HRO team communication	574	4.21	0.61	.86	.48**	.58**	1.00		
4. Respectful interrelating	574	4.41	0.53	.82	.46**	.54**	.56**	1.00	
5. Learning communication	574	4.01	1.03	.75	.26**	.28**	.44**	.23**	1.00

Note. HRO = high reliability organization.

**Indicates a significant correlation at $p < .001$.

Supervisor inclusive communication refers to the ways in which supervisors engage with subordinates to both solicit and accept input, and to encourage subordinates to express alternative viewpoints (Nembhard & Edmondson, 2006). It was measured using five items adapted from and extending Nembhard and Edmondson's (2006) three-item scale. Three items assessed how supervisors solicit input from members, while two items addressed how supervisors receive input. Sample items included "my boss actively sought input from a broad range of folks when making decisions" and "my boss actively listened when different views were presented" (1 = *strongly disagree* to 5 = *strongly agree*). These items produced a unidimensional construct with acceptable factor loadings (.66-.77) and internal reliability (standardized Cronbach's $\alpha = .88$).

Cross-level facilitation refers to ways that those in leadership roles (generally supervisors) throughout the chain of command conveyed and facilitated big picture understandings of the incident, managed subordinates' workload and skill development, and were available to provide assistance when needed (see Weick & Sutcliffe, 2007). It was measured with five items, including "leaders were constantly monitoring workload and span of control to reduce them when that became necessary" and "it was generally easy to obtain expert assistance when something came up that we didn't know how to handle" (1 = *strongly disagree* to 5 = *strongly agree*). These five items produced a unidimensional variable (loadings .51-.61) with acceptable internal reliability (standardized Cronbach's $\alpha = .81$).

Respectful interrelating refers to members interacting in ways that demonstrate that they attend to each other (Vogus, 2004; Weick & Roberts, 1993). It

was measured with four items, which include “individuals paid attention to what others were doing” and “we honestly reported what we perceived to each other” (1 = *strongly disagree* to 5 = *strongly agree*). These four items produced a unidimensional variable (loadings .45-.83) with acceptable internal reliability (standardized Cronbach’s $\alpha = .82$).

Learning communication refers to postincident discussions in which members talk about what they learned from the incident and recommended changes for future activities. It was measured with three items, which include “after the fire, we discussed what we learned” and “changes to procedures were recommended as a result of what we learned from our experiences on this incident” (1 = *almost never* to 5 = *almost always*). These three items produced a unidimensional variable (loadings .46-.82) with acceptable internal reliability (standardized Cronbach’s $\alpha = .75$).

SEM

The CFA and SEM for the hypothesized model were assessed using STATA MP (Version 14). A Satorra–Bentler adjustment with robust maximum likelihood estimation was used because the data were kurtic, which is common in social science data sets (Satorra & Bentler, 1994). Kurtic data violates the assumption of normality upon which SEM depends (Kline, 2011; Satorra & Bentler, 1994). The Satorra–Bentler scaled chi-square test for model goodness of fit is robust to nonnormality (more so than the saturated model) because it downwardly adjusts the value of the model’s χ^2 to reflect the level of kurtosis in the data (Kline, 2011). All model parameters in Figure 2 are standardized. Several fit indices were used to assess how well the model fit the data, and the Satorra–Bentler adjustment was applied to the chi-square, CFI, and RMSEA fit statistics. The chi-square test assesses the degree to which the sample and fitted covariance matrices differ; an insignificant result ($p > .05$) indicates good model fit (Kline, 2011). The CFI compares the sample covariance matrix with the null model, assuming all latent variables are uncorrelated; values greater than or equal to .95 indicate optimal fit, but values greater than .90 are acceptable (Hu & Bentler, 1999). The RMSEA indicates how well the model would fit the population covariance matrix if it contained the optimal number of parameter estimates; this test favors parsimonious models, and values below .07 indicate good fit (Steiger, 2007). Finally, the SRMR tests the extent to which the residuals of the sample covariance matrix differ from those in the hypothesized model’s covariance matrix; values lower than .08 are acceptable (Hu & Bentler, 1999).

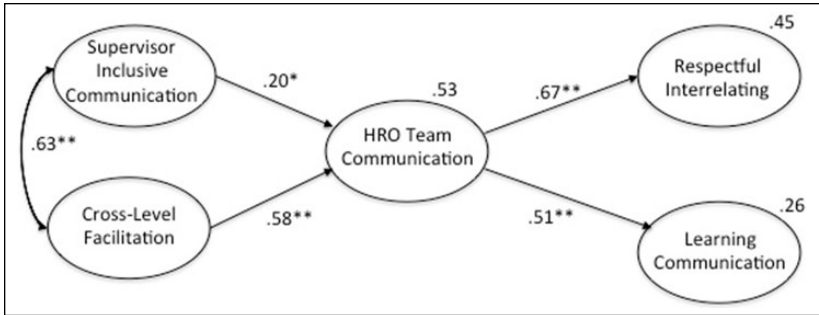


Figure 2. Structural equation model of high reliability communication in a hierarchy.

Note. Parameter estimates are standardized. The path coefficients are significant at either the $*p < .01$ or $**p < .001$ significance levels. The numbers to the upper right of the endogenous variables are the multiple R^2 values. The manifest variables and error terms are removed from this figure for visual clarity. HRO = high reliability organization.

Results

Results showed that the hypothesized model adequately fit the full data set ($N = 574$): $\chi^2(247) = 432.34$, $p < .001$, CFI = .95, RMSEA = .036, SRMR = .054. Figure 2 presents the model's standardized estimates, significance levels, and multiple R^2 values. The chi-square test was significant, which typically indicates poor fit. However, this test is sensitive to sample size such that larger samples like this one will commonly yield significant results (Kline, 2011). As such, it is important to consider the other fit indices, which all show acceptable model fit.

The first set of paths depicts the influence of supervisor inclusive communication and cross-level facilitation on each other, and on HRO team communication. Supervisor inclusive communication and cross-level facilitation covary ($\beta = .63$, $p < .001$), supporting H1. Both supervisor inclusive communication ($\beta = .20$, $p < .01$) and cross-level facilitation ($\beta = .58$, $p < .001$) significantly and positively predicted HRO team communication (accounting for 53% of its variance), supporting H2 and H3. Cross-level facilitation was a stronger predictor for HRO team communication than was supervisor inclusive communication. The second set of paths shows that HRO team communication is strongly and positively associated with members' respectful interrelating ($\beta = .67$, $p < .001$), that is, their efforts to collectively assess their circumstances, and interact in a respectful manner. HRO team communication accounts for 45% of the variance in respectful interrelating, providing

support for H4. Finally, the extent to which a team engages in HRO team communication predicts that group's inclination to engage in learning communication to examine previous actions and prepare for future situations ($\beta = .51, p < .001$), providing support for H5. HRO team communication explains 26% of the variance in learning activities.

Discussion

This study builds on the descriptive HRO principles to propose and test an explanatory model of communication in HRO hierarchies. Our model suggests that the enactment of HRO principles is facilitated by particular supervisory and within-group communication patterns and practices that might dampen unproductive hierarchical behaviors, such as overattention to status or positional authority, while maintaining productive aspects of hierarchy necessary for safety in dynamic environments. In particular, the model proposes how members of strongly hierarchical organizations might navigate hierarchy by promoting communicative patterns and practices that result in the sorts of collective information gathering and sensemaking characteristic of the flattened organizational arrangements Weick and Sutcliffe's (2015) HRO principles suggest. This model directly addresses hierarchical and communicative challenges to HRO that previous researchers have identified (Barton & Sutcliffe, 2009; Blatt et al., 2006; Nembhard & Edmondson, 2006). Specifically, the model shows that supervisory behaviors to actively seek input on operations, provide expertise and resources, and maintain appropriate workload create a foundation for internal team sensemaking and organizing (i.e., HRO team communication). Moreover, the model proposes that communication plays a more complex and foundational role in high reliability organizing than simply information exchange. Specifically, this study points to the importance of considering the HRO principles in relation to (a) how chains of command, comprised of members and groups, enable requisite variety through fostering an interactional culture with respectful affect; (b) how leaders cultivate cross-level awareness (i.e., "the bubble") through taking on a midsystem orientation to an operation; and (c) how team communication practices enact local safety culture.

Fostering Requisite Variety Through Cultivating Respectful Affect

HRO theorizing assumes a flat hierarchy; however, supervisors throughout the hierarchy play crucial roles in making HRO behaviors possible. According to our model, the relationship between supervisor inclusive communication and cross-level facilitation (H1) suggests that we might expect supervisors

who communicate in ways that both solicit and internalize member input (i.e., inclusive communication) might also show greater concern for subordinates through monitoring their workload, looking out for problems, and through being readily available to offer assistance when needed (i.e., cross-level facilitation, see Table 1). That is, patterns of inclusive communication between supervisors and subordinates create an affective communication climate that welcomes input and enacts supervisors' concern for subordinates' workload, both of which provide a foundation for HRO team communication. Furthermore, supervisor inclusive communication moderately predicted HRO team communication (H2). Together, these communication patterns set the stage for requisite variety.

The term *requisite variety* suggests that organizational systems with a great deal of complexity need their members to resist the urge to simplify their understandings of environments and their actions in response (Weick, 1987, adapted from Ashby, 1962). Requisite variety is accomplished through incorporating multiple, divergent perspectives, and it forms the foundation of each HRO principle in some way. For instance, *deference to expertise* calls on members to welcome input from those with particular expertise, regardless of hierarchical rank. *Sensitivity to operations* involves tracking and attending to subtle and unexpected cues observed throughout the activity system and finding ways to incorporate seemingly random information into a coherent understanding of the circumstances. *Reluctance to simplify interpretations* calls on members to question whether past methods are appropriate in the present moment. Hence, the complexity by which members respond to complicated environments is found in input from lower ranking but knowledgeable personnel, in responses to subtle cues that seem disconnected from everything else, and in the effort it takes to break away from standard practices and improvise a new approach to a new situation. As such, requisite variety is difficult to achieve because its sources often are the organization members who are easiest to dismiss, the scraps of information that are easier to ignore than deal with, and the actions that are easier to reproduce than to reinvent. Hierarchical organization structures are designed to minimize the number of decision makers and to streamline input. As such, hierarchy impairs requisite variety by prioritizing certain voices over others and through standard procedures that leave little room for improvisation (LaPorte & Consolini, 1991). However, the present study suggests how members might work around these common obstacles. In particular, considering ways that hierarchy is enacted through communication patterns and practices between supervisors and subordinates, and among team members, directs attention toward ways that communication accomplishes more than just information exchange. Our model suggests that high reliability organizing relies on the ability of members throughout a chain

of command to cultivate respectful affect in their interactions—one-on-one, across the hierarchy, and within work groups.

Requisite variety is achieved through incorporating multiple and divergent perspectives, and by relying on rich communication (Weick, 1987). Our study shows that one way to navigate hierarchy to enhance requisite variety is through supervisor efforts to enact inclusive communication patterns. Supervisor inclusive communication shapes the affect of the relationships with and among subordinates, as the extensive work on psychological safety by Amy Edmondson and colleagues has shown (Detert & Edmondson, 2011; Edmondson, 1999; Nembhard & Edmondson, 2006). Moreover, the relationship between supervisor inclusive communication and cross-level facilitation appears to be about more than simply coordinating action; it is about building a relationship that shows genuine concern between supervisor and subordinate regarding the details and needs of the operation. The supervisor actively engages the subordinate in identifying problems and solving them, which then likely helps the subordinate take more ownership over his or her actions and his or her part in the process, and likely deepens the groups' repertoire for action.

From Having the Bubble to Carrying It

Our model suggests that supervisors throughout a chain of command are in advantageous positions to develop an understanding of the larger system to which their and their subordinates' actions contribute. The finding that cross-level facilitation was a moderately strong predictor for HRO team communication (H3) suggests that supervisors' efforts to check in with members, monitor their work, and provide assistance possibly helped generate the kind of proactive communicative culture needed to enact HRO team communication. In early HRO research, theorists referred to the importance of "having the bubble" (Roberts, 1993), which meant that members developed an understanding of what the system as a whole aimed to accomplish and imagined how various actors contributed to the system's goals (see also Roth, Multer, & Raslear, 2006). Roberts (1993) suggested that *having the bubble* was the responsibility of all members equally. Our study indicates that leaders throughout the chain of command play crucial and precarious roles in communicating cross-level awareness of incident operations through cultivating *deference to expertise*, *commitment to resilience*, and *sensitivity to operations*. Instead of all HRO members "having the bubble," our findings suggest that cross-level facilitation activities of supervisors throughout a chain of command might serve to *carry*, *update*, and *share the bubble* with others as a situation unfolds. That is, those in supervisory roles engage in cross-level facilitation, linking local action to big picture goals, and vice versa.

Team Communication Patterns Enact Safety Climate

Teams create their own safety climates through the communication patterns and practices they locally adopt, maintain, and hold themselves accountable to. In the present study, HRO team communication strongly predicted members' respectful interrelating (H4) and learning discussions (H5). These paths suggest that enacting HRO team communication engages members in patterns of communicative inquiry while responding to an incident, and that these patterns of inquiry both foster respectful interactions and lend themselves to retrospective learning discussions. These findings substantiate a recent move in which studies conducted on HRO contexts attend to the work group level of analysis (see Jahn, 2016; Krieger, 2005; Myers, 2005; Myers & McPhee, 2006; Vogus & Sutcliffe, 2007). The basis for attention on work groups, rather than entire organizational systems, is that work groups are the locus of membership. Members are not only socialized into work group sub-cultures and collective identities, but they also are held accountable to participate in practices (e.g., learning discussions), and to honor local behavioral norms (e.g., interacting respectfully). This study suggests that practices and norms for communication are especially important for addressing concerns, questions, and insights regarding safety and risk in wildland firefighting (and likely other emergency services, too).

Practical Implications

This study contributes to the practice of high reliability organizing by advancing an understanding of communication in HROs that moves beyond message transmission and information exchange. Instead, by making communication central to the model, we advance new understandings about how HRO teams foster communicative practices and patterns that might cultivate respectful affect and learning on the team. Our findings should be considered in relation to previous efforts to facilitate practical implementation of HRO principles. Specifically, Weick and Sutcliffe (2001, 2007) suggested that organizations *audit* their existing activities to identify sources of, and obstacles to, reliability. One way to extend these findings to practice is to reconsider how HRO audit questions might account for communication and hierarchy in HROs in more nuanced ways by directing attention toward communicative patterns and practices that enact voice *in the midst of* hierarchical relationships.

Auditing voice and participation. Research often casts employee voice as an individual discretionary behavior, meaning that individuals choose to

participate, remain silent, or speak up based entirely on their own volition (see Morrison, 2011). Although numerous studies address how the supervisor–subordinate relationship enables and constrains voice (Brueller & Carmeli, 2011; Edmondson, 1999; Nembhard & Edmondson, 2006), more research should consider how voice is also a broader social process, emerging from work group subcultures and professional value systems (see Morrison, 2011, for this critique). To further enrich understandings of voice in HRO contexts, researchers and practitioners could examine how organizations influence opportunities for dialogue, encourage and discourage authentic participation, and create conditions for accountability at all levels (Jahn, Putnam, & Myers, 2017). Organizational audit questions should examine both formal and emergent communicative practices, particularly in work groups (e.g., teams, units, modules, etc.). Questions might ask, “How do communicative practices call on members to participate, and in what ways?” “How do communicative practices create forums for voice?” “How are communicative practices connected with local symbolic concerns and identity work?” “How do communicative practices participate in members’ efforts to perform collective identities and reputations?” and, “How do organizations handle (i.e., reward, punish, ignore) receiving undesirable information?”

Limitations and Future Directions

Although this study is strengthened by a large, random, stratified sample, there were several limitations. First, the survey asked individuals to assess their immediate work unit on their most recent fire event. Thus, the survey assessed group-level variables at the individual level and did not allow for comparison across work groups. The reason the survey focused on individuals rather than groups was because, as we explained in the “Method” section, participants were reporting on their *most recent fire event*, which might have involved acting in their regular organizational role *or* in a temporary role within the ICS structure. Second, wildland firefighting involves various types of personnel configurations. It is important to note that the model might reflect some work unit types more than others, depending on the proportions of unit types represented in the sample. Third, because this was a cross-sectional survey, it is not possible to know for certain the causal direction among variables in the model. However, analyses followed standard SEM procedures to determine the hypothesized paths and their directionality based on previous research and theoretical reasoning (see Kline, 2011), and the model fit the data adequately. Fourth, the measures for HRO team communication, cross-level facilitation, and respectful interrelating each in some way assess high reliability organizing and were moderately correlated with each other. It

is possible that the moderate beta and multiple R^2 values among these model variables are due to these sets of items each measuring subdimensions of HRO. Nevertheless, the EFA and CFA results show that each of these measures assesses distinctive sets of activities.

This research described a model for the wildland fire context; future research should test the model on different on more HRO work groups, and exemplary HROs that are hierarchically based. It would also be useful to examine how certain communicative practices facilitate (or obstruct) adaptive action and communication, and what social factors contribute to maintaining or hindering such practices in work groups.

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