Changing Interaction Dynamics in Hierarchical Groups: Evidence from a Role Expansion Field Experiment in Healthcare

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ABSTRACT

Relational inertia arising from formal roles and status hierarchies is endemic and problematic in many organizations. This study examines how role-power expansion for those in the middle of hierarchical groups, a central but understudied population, affects network structure and the nature of interactions within these groups. To do so, we conducted a field experiment assessing the effect of a formal role expansion for nurses involved in primary care delivery on interactions within hierarchical care groups. We utilized wearable social sensors to collect second-by-second data on face-to-face interactions, conversational characteristics, and body movements which allowed us to study who interacted with who in workgroups, as well as how interactions occurred. We find that role-power expansion in hierarchical contexts can produce structurally desired effects and is one means of overcoming relational inertia. However, it ignites more contentious interactions, a response consistent with increased tension and status renegotiation in reaction to greater power of the middle. Our study contributes to research on the interplay of formal and informal organization and network dynamics by documenting a key mechanism by which relational inertia can be overcome and analyzing the complexity in social interactions that can arise when this change occurs in hierarchical workgroups.

Keywords: role change, relational inertia, formal organization, informal organization, hierarchy, social networks, field experiment, health care
Hierarchies are ubiquitous in social and organizational life. Formal hierarchies defined by vertical lines of position-based bureaucratic authority are the archetypical modern organizational form (Leavitt, 2005; Powell, 1990; Weber, 1921). Furthermore, informal hierarchies, which emerge through patterns of informal social relations, interactions, and social networks, and place individuals and groups in dominant or subordinate positions as formal hierarchies do, characterize much of life both inside and outside of organizations (Diefenbach & Sillince, 2011; Martin, 2009). Although both forms of hierarchy govern patterns of interaction within organizations and often ultimately influence organizational performance, scholars have focused historically on either formal or informal organization (McEvily, Soda, & Tortoriello, 2014). Beyond the insightful demonstration that position within the formal organizational hierarchy is a primary determinant of location in the informal organization - structurally in terms of social networks (Han, 1996; Kleinbaum, Stuart, & Tushman, 2013; Lincoln & Miller, 1979) and relationally in terms of the status (Magee & Galinsky, 2008) – research and theory has largely neglected the interplay of these two organizational arrangements (McEvily et al., 2014).

The interplay of formal and informal organizational hierarchy is a notable gap, worthy of investigation, for two reasons. First, we know - from observation and experience - that no organization operates purely as prescribed formally nor allows purely emergent informal actions to determine its fate. Focusing therefore on one without the other is unlikely to provide a full account of organizational behavior and outcomes (Barley & Kunda, 2001; McEvily et al., 2014). Second, the interplay of these organizational arrangements contributes to an important problem for many organizations: inertia. Attempts to bring about organizational improvement through formal restructuring are often thwarted or slowed by inconsistencies between formal and informal organization (Crozier, 1964; Gulati & Puranam, 2009). In particular, relational inertia,
holding onto existing relations and relationships, often undermines formal organizational change efforts (Briscoe & Tsai, 2011; Gargiulo & Benassi, 2000).

Existing research has provided limited insight about how relational inertia can be overcome. In part, this reflects the fact that most work on social networks, the core of informal organization, is static. There is a paucity of research on network dynamics and change (Ahuja, Soda, & Zaheer, 2012). Emerging work on catalysts of network change largely focuses on disruptive macro-level events like mergers and acquisitions (Briscoe & Tsai, 2011) or organizational restructuring (Srivastava, 2015a). This work shows that disruptive macro-level events can produce pronounced changes in intraorganizational social networks that are unexpected (Briscoe & Tsai, 2011). Scholarly work suggests that purposeful changes in formal organizational structure or work redesigns could also bring about consequential changes in informal organization (Srivastava, 2015b). However, there is limited empirical work that allows for causal inferences to be made about the anticipated and potentially unanticipated consequences that these planned change initiatives may have on interactions within organizations. Little is known about how formal changes alter informal organization in terms of who interacts with whom and how members converse with one another.

In this paper, we examine how a role change that expands power for those in the middle of the formal hierarchy alters network structure within workgroups and the nature of those interactions. We focus on the middle of the hierarchy because change for this group presents an opportunity to explore the potentially cascading impact of this theoretically relevant yet understudied group. We argue that role change in the middle can counteract inertia but can also produce undesired effects in hierarchical contexts by escalating status renegotiation and tension, which induce contentious rather than collaborative behavior (Bendersky & Hays, 2012). While
much research exists on status construction (Ridgeway, 2006), research examining how variations or changes in status structures affect the behavior of actors within them remains scant and theories of how status changes are largely absent from the literature (Sauder, Lynn, & Podolny, 2012).

To advance the field in this regard, we conducted a field experiment to assess the effect of a formal role expansion for nurses involved in primary care delivery on interactions within hierarchical care groups. To examine both the structure and nature of social interactions, we collected second by second data on face-to-face interactions, conversational characteristics, and body movements using wearable social sensors. In sum, we found that the role expansion for nurses altered interactions throughout care groups, undoing relational inertia and changing how group members interacted. The change contributed to the development of a social network structure consistent with the planned change goals, but also a structure that threatened groups’ ability to perform well overall due to the quality of the interactions within the new structure. We observed an escalation in conversational behaviors that are problematic for collaboration - decreased listening and increased interruptions - by members of the group across the professional hierarchy. Ironically, the more centralized formal and informal structure created more distributed and contentious interactions, a response consistent with status renegotiation and tension in reaction to greater power of the middle, and also a worrisome response because status tension is a key source of poor group performance (Bendersky & Hays, 2012).

Our study makes four main contributions. First, it advances understanding of the co-existence and interplay of formal and informal organization, and in doing so, develops our theoretical and practical knowledge of relational inertia and the evolution of organizational interactions. We show that formal organizational change via work-role redesign is a key way in
which relational inertia can be overcome, and document the complexity in social interactions that can arise when this change occurs in hierarchical workgroups. Second, our study advances understanding of the structure and nature of interaction – the who and how – in social networks. How network members interact has received limited attention previously. Our study opens this new area of research focused on the micro-processes within social networks, and how they structure change. Methodologically, it shows the feasibility of using wearable sensors to study network change processes. Third, our research expands the study of “the middles” in professional hierarchies. Prior work discusses the advantages and disadvantages of being in the middle. We show the power of the middles in shaping workgroup interactions, and how their status gains change workgroup dynamics for all.

Finally, this work has significant implications for research and practice in healthcare management. Role expansion for nurses, in which nurses formally serve as care coordinators for patients, is being considered and implemented as a strategy for addressing a root cause of quality and cost problems in healthcare: coordination failures. More than forty percent of patients report experiencing coordination failures (Schoen et al., 2011) and such failures costs the United States’ healthcare system $25-45 billion annually (Burton, 2012). Recent legislation in the U.S. and Western Europe proffers role changes, like the one we study, as a solution (e.g., Patient Protection and Affordable Care Act 2010). Emerging research however shows mixed results for this strategy. Our results provide an explanation for why some organizations see no benefit: The virtue of this role re-design in principle can be undermined by the quality of the interactions fostered by this change within the hierarchical medical environment - unless well-managed.

UNDERSTANDING FORMAL ROLE CHANGE: A LITERATURE REVIEW

Professional Roles and Status Hierarchies as Sources of Relational Inertia
A large body of work has shown that organizational inertia or the resistance by firms to changes in their formal structure, work processes, and policies arises from a host of factors ranging from competency traps and localized search (Cyert & March, 2004) to legitimacy pressures and the need to be seen as reliable and reproducible (Hannan & Freeman, 1984). Rigidities in formal structure arising from inertial tendencies at the firm level likely contribute to relational inertia in intraorganizational networks given the close coupling of formal organizational position and patterns of informal interaction. Compared to the large body of work on organizational inertia, very little research has examined the micro-processes that generate or negate tendencies toward relational inertia (Briscoe & Tsai, 2011).

At the micro-level, both structural and cognitive processes can give rise to relational inertia. Structurally, homophily, reciprocity, and cohesion produce a tendency within networks for actors to engage in repeated interactions and for networks to become more fixed over time (Granovetter, 1973; Portes & Sensenbrenner, 1993). Researchers have found that homophily, similarity in characteristics within an individual’s network (e.g., women in a woman’s network), motivates relational inertia because individuals are reluctant to break bonds with those with whom they identify, in a sense denying self (McPherson, Smith-Lovin, & Cook, 2001). Prior work has also shown that tendencies toward reciprocity and dense cohesive networks generate relational lock-in (Maurer & Ebers, 2006). For instance, Gargiulo and Benassi (2000) found that managers with cohesive networks are not as able to adapt their networks to meet the challenges arising from new task requirements as managers with networks rich in structural holes.

The cognitive and normative processes underlying relational inertia are often as important as the network structures themselves (Ahuja et al., 2012). Mauer and Ebers (2006) observed that shared identities and routines, which contribute to cognitive lock-in, coupled with networks
characterized by intense and frequent interactions among a limited range of partners produced relational inertia in the biotech companies they studied. Of particular interest for our study are the cognitive and normative processes that arise from hierarchical patterns of interaction that are likely to generate relational inertia. Hierarchies, whether they are formally constituted or emerge through repeated social interactions, tend to be self-reinforcing and produce stable patterns of social interactions (see Magee & Galinsky 2008 for a review). Generally, those with power (control over resources including skill and knowledge) tend to be highest in the hierarchy and to have higher status (respect and esteem in the eyes of others), which often leads to more power, making power and status reinforcing states, and reinforcing of hierarchy.

Given the myriad benefits that accrue from higher status (access to scarce resources, social support, longer life span, etc.), higher status actors tend to defend their social position by, for example, disassociating themselves from lower status actors and engaging in dominance behaviors to assert their position in the social hierarchy (Chen, Peterson, Phillips, Podolny, & Ridgeway, 2012; Sidanius & Pratto, 1999). Lower status actors, even though they are disadvantaged in the hierarchy, often accept and internalize hierarchy, acknowledging the stability that comes with knowing place and expectation (Jost, Banaji, & Nosek, 2004). As such, attempts to change patterns of interactions within organizations are often met with resistance, particularly if they challenge existing professional jurisdictional boundaries (Abbott, 1988; Kellogg, 2014) or status-power orders (Bendersky & Hays, 2012; Kellogg, 2012).

Rather than change, individuals tend to reproduce status hierarchies in both their network structure (Gould, 2002) and the nature of their interactions within them (Fragale, Sumanth, Tiedens, & Northcraft, 2012), contributing to relational inertia. Those highest in the status hierarchy, in the formal or informal organization, tend to occupy the most central position in a
network (Freeman, 1977; Wasserman & Faust, 1994). As they interact with others in their network, they further reinforce the hierarchy via dominance and deference behaviors, the accumulation of which conveys status. Individuals use subtle communication and deference behaviors when negotiating and navigating organizational hierarchies (Fragale et al., 2012). Lower status members tend to interrupt less often than their higher status counterparts (Hall, Coats, & LeBeau, 2005) and those with greater influence listen more (Johnson & Bechler, 1998). Verbally, deference is often conveyed through hedging (Fragale, 2006) and using a hesitant tone (Ridgeway, 1987). Nonverbally, behaviors such as averting eyes, smiling, and slouching, can also convey deference (Hall Coates, LaBeau 2005). Since status hierarchies require continual re-enactment we expect to see status-generated relational inertia conveyed not only through network position—who interacts with who—but also by the nature of those interactions.

**Formal Role Change as a Strategy for Overcoming Relational Inertia**

Although relational inertia can be functional, it can also be unproductive for organizations, a situation that ushers consideration of how to overcome it. The emerging work on this subject has demonstrated that macro-organizational changes, such as mergers or large-scale organizational redesigns, can help organizations overcome inertia (Allatta & Singh, 2011; Briscoe and Tsai 2011), in large part because of the ambiguity that they create (Srivastava, 2015a). We expect that another, quite different type of formal organizational change, formal role change, can also undo inertia.

Roles demarcate the rights and duties, expertise and responsibilities, and expected behavior of the role occupant (Biddle, 1986). A professional role change thus alters what workers in the profession do, thereby changing professional-role boundaries (Barley, 1986; Turner, 1990). Such changes can involve the creation, expansion, minimization, or dissolution of a role. Because
roles have functional or representational links to one or more other roles, change in one role can mean change in a system of roles, and even when it does not, role change still registers for those in other roles because it highlights the ambiguous possibility for different formal and informal organization. Barley (1986) observed, in his qualitative study of the introduction of CT scanners in hospitals, that the role change for technologists (to become scanner users) presented an “occasion for [new] structuring”. Consistent with the theory of negotiated order within the professions literature (Strauss, 1978), he observed that the role change prompted re-negotiation of the work and social order between radiologists (high status) and technologists (lower status), and restructuring of their interactions.

Integrating then the literatures on professions, roles, and formal and informal organizational change leads us to expect that formal role change will disrupt relational inertia because the change presents an ambiguous opportunity for restructuring. This is suggested by work such as Barley’s (1986) aforementioned study and Kellogg’s (2014) comparative ethnographic study that showed that simultaneous role expansion for doctors and lawyers (two high status professions) to facilitate access to healthcare changed the nature of their interactions. Interestingly, success at implementing this change was enabled by the creation of a new brokering role for a lower-status group, community health workers. These studies demonstrate the potential for formal role change at the higher (doctors/lawyers) or lower (technologists) end of hierarchy to shift formal and/or informal organization. In these accounts, the middle of the hierarchy is ignored.

We expect that formal role change at the middle would also be disruptive, and more so, because of the middle’s centrality and status ambiguity (Gould 2002). Role expansion in the middle of the hierarchy has the potential to change interactions with those higher and those lower
in the hierarchy, and thus alter the entire system of organization and interaction. While this may allow relational inertia to be overcome, it could also be severely disruptive and generate unanticipated consequences.

**Unanticipated Consequences of Overcoming Relational Inertia**

A key mechanism that could generate unanticipated micro-level consequences to planned role changes in hierarchical groups is status conflict. Since status hierarchies require continual re-enactment, they are dynamic and can be contested when the opportunity for such presents itself (Bendersky & Hays, 2012). Research examining how variations or changes in status structures affect the behavior of actors within them remains scant and theories of how status changes are absent from the literature (Sauder et al., 2012). The little empirical and theoretical work that does exist suggests that ambiguity and a lack of rigidity in status hierarchies are likely to produce tension and conflict among their members (Gould, 2003). Status conflicts or disputes over people’s relative status positions in their group’s social hierarchy (Bendersky & Hays, 2012) are particularly pernicious because their effects are persistent and likely effect the entire network of social interactions (Blau 1964; Gould 2002). Moreover, status conflicts can have negative effects on group performance (Bedersky and Hays 2012). The negative effects of status conflict are likely to be most maleficent among members of hierarchies who are closest in rank (Gould, 2003).

Since relational inertia arising from status maintenance mechanisms is likely reflected in both network structures and the nature of interactions taking place within those networks, status tension and conflicts arising from planned changes in role structures should also manifest in a similar manner. More specifically, we anticipate that in periods in which status structures are stable and relational inertia continues unperturbed, we should not expect to see meaningful
changes in network structure or conversational characteristics. However, when role changes overcome relational inertia we should not only see changes in the structure of networks but also changes in how participants communicate, particularly if the role changes usher status tension and conflict.

**EMPIRICAL SETTING: THE CASE OF FORMAL ROLE CHANGE FOR NURSES**

As mentioned above, our setting for analysis of how formal role change affects informal organization (who interacts with who) and conversational characteristics (how they interact) in hierarchical groups was healthcare delivery. This setting was ideal for theory development and empirical investigation for three reasons. First, the existence of a professional hierarchy in medicine and the differential status accorded to those in different disciplines has been well established in the sociology of professions and healthcare literatures (Abbott, 1988; Freidson, 1970). Second, this setting emphasizes roles, both to enact the professional hierarchy and to facilitate patient care, which often requires the integration of activities across roles and thus a need to define roles. Finally, many organizations are actively considering and implementing role changes of this type as a strategy to improve quality of care and reduce healthcare costs.

Formal role change is seen as way to address a root cause of quality/cost problems: the preponderance of coordination failures (e.g., test results or records not available at time of appointment, providers failing to share important information with each other, etc.) (Schoen et al., 2011). Each year, coordination failures contribute to millions of medication errors, health complications, unnecessary testing, preventable hospitalizations, and patient mortality (Burton, 2012). As a solution to these failures, several have proposed the formal expansion of the nursing role to include care coordination, defined as “the deliberate organization of patient care activities
between two or more participants (including the patient) involved in a patient’s care to facilitate the appropriate delivery of healthcare services” (McDonald et al., 2007). This role entails managing the care process, including development and communication of care plans within and across care teams and settings, engaging directly with patients to support their health, and ensuring that all needed care is arranged and delivered (Nutt & Hungerford, 2014). In assuming this role, nurses work at the very “top of their license” and formally gain greater responsibility for the care of panel of patients. Thus, this role, even though it does not change ordering within the professional hierarchy (nurses in the middle between physicians and allied health professionals such as medical assistants), inherently makes nurses more central in care delivery and increases the power, authority and autonomy of nurses in the formal hierarchy. Historically, although nurses have been recognized as well-suited for this role and stellar in performing it when they have (Camicia et al., 2013), they have not formally held this role, nor has any other team member, hence the many coordination gaps experienced by patients. The addition of this role to nursing is thus a role change, but not a role transfer from one professional group (higher or lower-ranked) to another.

The belief is that having nurses assume the coordination role, acting as a bridge between care team members, will improve quality and reduce costs because it will enable better teamwork as a result of better information processing and improved efficiency in care tasks performance (Camicia et al., 2013). Studies of nurse care coordination however have produced mixed results about effectiveness (e.g., Atherly & Thorpe, 2011; Peikes, Chen, Schore, & Brown, 2009). Such mixed results have raised the issue that we examine: what actually happens within groups when this role expansion occurs. This insight is needed to understand why the industry observes no significant improvement and instead inertia in interactions in many cases, despite the promise of
this nurse role expansion for creating more productive formal and informal organization for care.

METHODS

Study Design: A Field Experiment

We studied the effects of a formal role expansion in the middle of a professional hierarchy on network position and conversational characteristics through a field experiment conducted at 12 community health centers affiliated with an organization that had decided to assign the role of care coordination to its nurses. These 12 centers, located in one state, deliver primary care to over 130,000 patients each year via approximately 410,000 patient care visits. Although the centers served patients of all backgrounds for all primary care needs, they have a special commitment to serving the uninsured, underinsured, and special populations (e.g., patients with HIV/AIDS, diabetes, and chronic mental health issues).

We were introduced to the organization shortly after its leadership decided that it would add care coordination to the role of its nurses. Per our discussions with the leadership, the change was motivated by an organizational self-study that revealed less coordination for their patients than they desired, and a desire to have all members of the care team function at the highest level of their training and licensure. Their observation was that nurses in their organization were not working at their highest possible level, which was dissatisfying to nurses and wasteful for the organization. Adding care coordination to the nursing role was viewed as a means to both improve care and maximize the nursing role for the organization and staff.

For operational reasons (e.g., having sufficient resources for training, maintaining cross-coverage between providers within county, etc.), the leadership decided to introduce the nurse role expansion to its sites in a new county every three months over the course of a year. This afforded us the opportunity to pursue a quasi-experimental research design. In our experiment,
the first six centers that introduced the nurse role change served as our intervention sites, while the remaining six centers, which would be introduced to the role change later served as our comparison sites. Relative to a cross-sectional analysis, the advantage of this experimental design is that it increases confidence that observed changes in the intervention group are not due to secular trends (via assessment of the comparison group) and are due to the role change, which was the only change at the centers during the study period.

Although sites were not randomly assigned to groups or purposefully matched, based on the results of Wilcoxon rank-sum tests, the intervention and comparison groups were similar at baseline and follow-up on most characteristics for which we were able to obtain data. We used rank-sum tests to compare group medians because we could not assume normality (required for t-tests) due to the small number of centers in our study. The results of these tests indicated that the intervention and comparison groups were similar \( (p \geq 0.05) \) in the number of patients visits per full-time employee, productivity (the percentage of target patient visits set by the organization that providers complete), patients eligible for care coordination (an indicator of the complexity and volume of work required), patients with private insurance, Medicaid, or uninsured, racial-ethnic composition of patients served, and years centers were affiliates of the organization. The groups only differed significantly with respect to percent of patients with Medicare as their health insurer \( (p=0.02) \). The overall match between intervention and comparison groups minimized a possible concern that changes that we might observe stemmed from a difference between groups in these core center characteristics rather than the role change.

**Implementation of the Nurse Care Coordinator Role at Study Centers (The Intervention)**

In the intervention centers, nurses’ role formally expanded to include care coordination for adult patients expected to benefit most from the program. These were defined by the
organization as patients who had complex care needs stemming from having multiple chronic medical and/or behavioral health diagnoses, chronic conditions (e.g., diabetes, hypertension, asthma, or chronic obstructive pulmonary disease) that are poorly controlled, and/or a recent discharge from an acute care setting or hospital emergency room. A patient could also qualify for nurse care coordination if a primary care provider (PCP) and/or nurse identified the patient as high risk or requiring complex care for any reason. Thus, the nurse role expansion in this organization gave nurses responsibility for a key patient group (high cost and most in need).

As part of their new role, nurses were expected to ensure coordinated care for these patients, and with that goal, lead a weekly panel management session held with the PCP and behavioral health staff. The sessions were to be used to identify patients who needed coordination, review patient progress, and plan coordinated care. This was a dramatic change in roles for nurses. Not only did it push them beyond what they had been doing, but also it forced all care team members to reassess their roles relative to nurses. Although the change did not alter positions in the professional hierarchy (PCPs were still at the top), the role change increased the authority, autonomy, and responsibility of nurses.

To implement the change, the organization introduced the nurse care coordinator role to all staff via meetings and other communications (e.g., email and newsletters). It also provided three resources to nurses to support their effectiveness in their new role: training in care coordination activities, a book that described the role and how to perform related tasks (“the playbook”), and an electronic dashboard designed to support their coordination activities. All of the nurses at the intervention sites (and eventually at the comparison sites when they transitioned) received 23 hours of training over a period of 2 to 3 months from experts hired by the organization. The training covered care plan development, documentation, panel management, transition care
support, motivational interviewing, self-management goal setting, chronic disease management (e.g., hypertension), and behavioral health disorders. The playbook provided instructions for each related tasks, information on additional resources, and measures to evaluate performance. A new electronic dashboard was integrated into the organization’s electronic health record system to facilitate nurse tracking of patients and activities. The organization further reinforced its commitment to the role change by monitoring nurse performance and providing feedback reports to nurses. In short, the intervention provided a new level of authority and responsibility to nurses by empowering them to care for high need, complex, and high cost patients.

**Data Collection**

We collected data at all sites—both intervention and control sites—at two times. The first time period, which we termed the “baseline” period, was one month prior to the start of nurse training in care coordination and installation of the electronic dashboard at the intervention sites. At that time, none of our sites had been exposed to the role change intervention. The second time period, which we termed the “follow-up” period, occurred eight months after baseline data collection. At intervention sites, this timing meant that staff in these sites had been exposed to the nurse role expansion for seven months: three months of training followed by four months of the new role in practice. Comparison sites had still not been exposed. Our follow-up period was set at four months after nurses assumed their new role in intervention sites for two reasons: 1) to ensure that intervention sites had sufficient time working under the role expansion such that the new role structure was familiar, and 2) to retain the non-exposure status of comparison sites. Due to the organization’s fixed roll-out plan, the first set of comparison sites was scheduled to be introduced to the nurse coordination program shortly after our follow-up period.

At baseline and follow-up, we asked all primary care professionals at the sites (PCPs,
nurses, medical assistants) to wear a sensor designed to capture interaction patterns and conversational characteristics at work for two weeks (Monday-Saturday). The sensors, which are about the size of a deck of cards, contain a Bluetooth sensor to measure physical proximity, an infrared detector to capture face-to-face interactions, a microphone to collect data on conversational characteristics, and an accelerometer for measuring posture and body movement. The wearable sensors were developed by Olguin and colleagues (2009) and sold by Sociometric Solutions. The validity and reliability of the sensors has been established in other studies (Chaffin et al., 2015; Dong & Pentland, 2010; Olguín et al., 2009; Pentland, 2008; Waber, 2013).

We obtained data from 136 individuals at baseline (62% of 219 eligible participants) and 139 at follow-up (72% of 194 eligible participants). Informed consent was obtained from all participants. Important in our context, where patient privacy is required by the Health Insurance Portability and Accountability Act (HIPAA), the sensors do not record speech content. Participation rates were higher at follow-up because we offered an incentive for participation, a $10 gift card to Dunkin’ Donuts or Starbucks, delivered at the end of the sensor-wearing period.

When we reviewed the data collected by the sensors, we observed that people were less likely to wear their sensors in the second week. Because we deemed it important to use the most complete data possible, we used only the data gathered in the first week of the baseline and follow-up periods. This resulted in 3,296 total hours of data at baseline and 2,792 hours at follow-up. Due to scheduling rotations, not every provider worked every day of the week. This yielded a final sample size of 457 person-days at baseline and 485 person-days at follow-up (942 person-days total). The characteristics of participants at baseline and follow-up at intervention and comparison sites are presented in Table 1.

**Measures of Network Position**
To better understand the relationship between formal role change, informal interactions, and relational inertia, we examined the effect of the formal power reallocation arising from the care coordination intervention on degree centrality, betweenness centrality, and network constraint. Using interaction frequency data from the sociometric sensors, we constructed a series of sociomatrices containing the number of face-to-face interactions taking place between each of the care groups for each day of our baseline and follow-up periods. While the sociometric sensors come with software to calculate a handful of network measures, we calculated values for the network metrics used in this study in the igraph package in R to ensure that our network metrics are consistent with those used in prior research and are easily reproducible.

Degree centrality. This most basic aspect of network structure refers to the number of others with whom a person is directly connected (Scott, 2012). In other words, it captures the number of interaction partners a person has. Inherently, degree centrality provides a quantitative measure of the size of a person’s social network, and thus can be thought of as a measure of power, direct influence, buy-in, or leadership (Borgatti & Everett, 2006; Wasserman & Faust, 1994). Teams in which the formal leader has relatively high degree centrality tend to have higher team performance (Balkundi & Harrison, 2006; Mehra, Dixon, Brass, & Robertson, 2006). Thus, we expected that degree centrality might differ as a result of the intervention and those effects may be moderated by formal organizational position. For our measure of degree centrality, we calculated the total number of others with whom a focal individual interacted and normalized this number by dividing by the maximum number of potential partners the focal individual could have interacted.

Betweenness centrality. Actors with high betweenness centrality connect otherwise disconnected others. More formally, betweenness centrality for a focal individual is defined as:
where \( g_{jk} \) is the total number of shortest paths connecting any two actors \( jk \), and \( g_{jk}(n_i) \) is the number that actor \( i \), the focal node, is on. An actor’s betweenness is the proportion of geodesics between all other individuals in a network that involve that actor (Wasserman & Faust, 1994). Betweenness centrality affords potential control over information flows and resources in a network (Freeman, 1977) and creates opportunities for brokerage, liaising, and gatekeeping (Hossain, Wu, & Chung, 2006). It has been shown to be associated with an individual’s ability to coordinate projects (Hossain et al., 2006) and studies have found individuals with high betweenness to be leaders and active participants in task-oriented groups (Mullen, Johnson, & Salas, 1991).

**Constraint.** Similar to betweenness centrality, constraint captures the extent to which an actor can exploit structural holes or non-redundant contacts in her network (Burt, 1992). Constraint is a more local measure of an individual’s autonomy and is defined as

\[
C_i = \sum c_{ij}
\]

where

\[
c_{ij} = \left( p_{ij} + \sum_q p_{iq} p_{qj} \right)^2; i \neq j
\]

and \( p_{ij} \) is the proportion of \( i \)’s direct interactions that occur with \( j \) and \( p_{iq} p_{qj} \) are the indirect alter-alter contacts in which \( j \) interacts with other contacts \( q \) in \( i \)’s network. Constraint runs from 0 to 1 with a higher number indicating that the focal individual’s network is more constrained. The more constrained an individual’s network, the fewer opportunities there are for a focal individual (\( i \)) to act as a broker since the network contains fewer structural holes. Put different, constraint captures the cohesiveness of an individual’s network (Gargiulo & Benassi, 2000).

Within the network literature there is considerable debate about whether networks that afford brokerage opportunities either by having low constraint or high betweenness centrality are
advantageous to individuals and organizations. On the one hand, network closure or cohesion facilitates coordination, trust, and the development of group norms (Coleman 1990; Podolny and Baron 1997). Importantly for this study, cohesion within teams aids in knowledge transfer (Reagans & McEvily, 2003) and internal cohesion coupled with external network range is associated with positive team performance (Reagans, Zuckerman, & McEvily, 2004). On the other hand, individuals with low constraint have access to more diverse sources of information, can derive benefits from negotiation, and tend to be more innovative (Burt, 1992). Moreover, those with less constrained networks are more readily able to adapt their networks to meet the challenges arising from new task requirements (Gargiulo & Benassi, 2000). Accordingly, when interpreting the effects of the intervention on network outcomes, we keep in mind the theoretical tradeoffs between network brokerage and closure.

**Measures of Conversational Characteristics**

In order to assess the effect that the intervention had on the nature of interactions within teams, we also analyzed individuals’ conversational characteristics: interruptions and listening.

*Successful Interruptions.* Based on the wearable sensor speaking algorithm, a successful interruption was defined as occurring when three conditions were met: 1) Person A was talking. 2) Person B started talking over A. 3) Person A talked for less than five out of the next 10 seconds after Person B started talking. The percentage of times in which the focal person succeeded in initiating an interruption out of all attempted interruptions was used as our interruptions measure. Prior research has established that speaker detection algorithms, which rely on comparisons of sound intensities for voiced segments, detect speakers with roughly 95% accuracy (Dong & Pentland, 2010).

*Listening.* Following previous work using wearable sensors to examine listening behavior
(Pentland, 2008), we defined listening as time in which the badge-wearer was silent and someone else they were in close physical proximity to was speaking. For our analysis, we focused on the percentage of time spent listening which we defined as:

\[
\left( \frac{\text{listening}}{\text{speaking} + \text{silent} + \text{overlapping} + \text{listening}} \right) \times 100
\]

**Analytic Approach**

We first calculated descriptive statistics for our outcome measures for the intervention and control group and compared values in the baseline and follow-up period using t-tests to assess whether there were any observable differences within the groups before and after the intervention. Using a difference in differences estimation strategy, a standard analytic technique for studies with a quasi-experimental design, we further evaluated whether the role intervention had a significant effect on network position and conversational characteristics within care groups. The technique evaluates whether the difference in values between baseline and follow-up for the dependent variable differs significantly between intervention and comparison groups. In other words, it evaluates whether the difference in differences between groups over the two periods is significant and provides adjusted effect sizes of the differences.

We utilized separate multivariate linear regression models for each our dependent variables: degree centrality, betweenness centrality, constraint, successful interruptions, and listening. The unit of analysis in all of our models was provider-day. To estimate the difference in differences, we included an indicator variable for time period that was set to 1 if assessment occurred in the follow-up period (versus baseline), site fixed effects, and an interaction term, “Role intervention group X Time period,” that was equal to 1 if the person worked at a center that expanded the nurse role to include care coordination and the observation was in the follow-up period. Put differently, for all persons exposed to the intervention, the role intervention-time
period interaction term was equal to 1 in the follow-up period. We report models with site fixed effects to capture non-time varying differences between centers in which people worked, including those that might affect informal organization such as size. In all models, standard errors were also clustered by provider. We included two person-level covariates in our models: profession and gender. We coded profession using indicator variables for the three focal professions (1=medical assistants, 2=nurses, 3=PCPs), and gender using 1=women and 0=men.

We report estimates from OLS regressions in order to facilitate interpretability and comparability across models. We also estimated alternative specifications to ensure that are results are not affected by functional form. Betweenness centrality was overdispersed at zero. To assess whether this affected our results, we also estimated models examining betweenness using a zero inflated negative binomial regression with values of betweenness rounded to the nearest integer. Both degree centrality and constraint are normalized to run between zero and one. To assess whether the boundedness of these dependent variables affected our results, we also estimated these models using a fractional response generalized liner model (Woolridge 2006; 2011).

After examining the difference in differences across the entire sample of participants, we repeated our analysis to examine the intervention effect by profession. First, to assess whether the effect of the intervention varied by role, we included interactions between role and each of the indicators (time period, treatment, and interaction) necessary for estimating the difference in differences. When we detected that responses to the intervention varied by role, we explored the size of these effects. We conducted separate regressions with an indicator for each profession (1 = focal profession e.g., nurse; 0 = other profession), the set of indicators for the differences in difference described above, and an interaction between profession and each of the indicators. Of
interest was the three-way interaction term created by interacting the profession indicator and the intervention effect indicator variable (Role intervention group x Time period x Profession). We assessed the significance of the coefficient of this new three-way interaction term to determine whether the intervention effect was greater for the focal profession relative to others. We then plotted the marginal means to assess the effect size for each profession in intervention and comparison groups. We conducted this analysis for network and conversational characteristics.

To extend the profession-related analysis related to network position, we examined the odds that an observed interaction occurred between members of different professional groups (e.g., medical assistant-medical assistant versus medical assistant-other profession, physician-nurse versus physician-non-nurse) at follow-up relative to baseline, comparing dyads of interaction in intervention and comparison sites. We again used a difference in differences design but here standard errors were clustered by dyad. Given the small number of pairs for this analysis (N=78), we regarded p-values of 0.05-0.10 as marginally significant.

RESULTS

Effect of Role Expansion for One on the Network Positions of All

The first goal of our study was to examine the effect that expanding power in the middle of formal the hierarchy had on network structure, and thus patterns of informal interaction throughout the organization. Table 2 shows descriptive statistics at baseline and follow-up for network measures across the entire sample and by group (intervention versus comparison centers). In the intervention condition, normalized degree centrality increased significantly from baseline to follow-up (0.58 vs. 0.71; p<0.001). Betweenness centrality in the intervention condition doubled between baseline and follow-up (0.16 vs. 0.32; p=0.04). There was not a significant difference in constraint between baseline and follow-up in this unadjusted analysis. In
the control condition, no statistically significant differences were observed between baseline and follow-up for any of the three measures.

The results of the difference-in-difference estimations analyzing the effect of the role expansion intervention on our three measures of network position for care group members are presented in Table 3. As noted earlier, we focus on the interaction variable (Role Intervention x Time Period) identifying whether a person worked at a center with the expanded nurse role after the intervention because it indicates the difference in the change between baseline and follow-up periods between those in intervention and comparison sites. Model 1 shows that this variable was positive and statistically significant with respect to degree centrality ($B = 0.259$, $p < 0.001$). Thus, group members in intervention sites became more connected following the role expansion for nurses. To contextualize the size of this effect, a standard deviation in degree is 0.30. Model 2 shows that a significant increase occurred in betweenness centrality at intervention sites in the follow-up period ($B = 0.242$, $p < 0.05$). The increase in betweenness as a result of the intervention was smaller than what we observed for degree but still substantial at a third of a standard deviation. Model 3 shows that the intervention did not have a statistically significant effect on constraint across the entire sample ($B = -0.01$, $p = 0.64$).

These results reported above were robust to alternate specifications that did not include site fixed effects but incorporated a treatment variable with standard errors clustered by site and provider. Similarly, the results from the fractional response generalized liner model and zero inflated negative binomial model are consistent with those reported here (degree centrality $B=0.58$, $p < 0.001$ and betweenness $B=0.17$, $p=0.04$).

Three-way interactions (Role Intervention x Time Period x Provider Type) to assess
whether the intervention had differential effects throughout the professional hierarchy indicated that profession moderated the effect of the intervention on degree centrality and network constraint, but not on betweenness centrality. **Figure 1a** plots the results of our analyses of degree centrality by profession. The most significant increase in degree occurred for medical assistants, the lowest status member of the workgroup ($B = 0.15, p = 0.03$). The social structure changed such that medical assistants shifted from having the fewest interaction partners to having the most of the three professions studied, even as members of other previously more connected, higher status professions increased their ties ($p$-values $< 0.05$).

As reported in Model 2 of Table 3, on average, the role change did not have a significant effect on constraint, our second marker of informal structure ($B = -0.01, p = 0.64$). Our analysis by profession, however, showed different effects by professional group. As depicted in **Figure 1b**, nurses became less constrained ($B = -0.09, p = 0.03$) as intended by the organization, and PCPs became more constrained ($B = 0.06, p = 0.02$). Lower constraint for nurses was consistent with organizational intent to have nurses gain access to more knowledge sources for coordinating care and ability to adapt, whereas PCPs’ higher constraint would allow for ease of coordination within group, complementary effects of the theoretical trade-off associated with constraint. There was no significant change in constraint for medical assistants ($B = 0.05, p = 0.22$).

To better help us understand the dyadic dynamics that might account for the differential effects of the intervention by professional group, we also examined whether there was a change in the odds that an observed interaction would occur among given dyadic pairs using a difference in differences estimation. The dyadic analysis produced results consistent with the degree results for medical assistants presented above. The probability that an observed interaction would occur
between a medical assistant interacting with a member of another profession (nurse or PCP) increased following the role change for nurses (OR = 2.21, p = 0.08). However, the likelihood of a nurse interacting with a PCP declined significantly (OR = 0.24; p = 0.06). Recall that we consider p-values less than 0.10 to be significant due to the small number of dyadic pairs. Full models available upon request.

Together, the degree centrality and constraint results indicate that a change that expands the role for one (in the middle of the professional hierarchy) can shift the network structure for all, overcoming relational inertia in who interacts with whom. The role change for nurses led to a changed structure not only for nurses but also for PCPs and medical assistants, even though their ranks in the formal professional hierarchy did not change.

**Effect of Role Change for One on Conversational Characteristics**

In addition to understanding how role change in the middle of the hierarchy impacts who interacts with who, we also wanted to observe the effect of the interaction on the nature of interactions within teams. **Table 4** presents the difference-in-difference estimates of the effect of the role change intervention on conversational characteristics. The interaction variable indicates that the enhanced role for nurses significantly changed how people conversed with others. The interaction term in Model 1 indicates that interruptions increased significantly following the role expansion for nurses (B = 6.78, p = 0.03). The interaction term in Model 2 indicates that listening decreased significantly (B = -2.25, p = 0.01). These effects were not moderated by profession.

**DISCUSSION**

The goal of this study was to examine how formal role-power expansion for those in the middle of the hierarchical groups, a central yet under-examined population, affects network
structure (who interacts with who) and the nature of interactions within these groups (how members converse with one another). We theorized that such change disrupts relational inertia by unsettling status hierarchies. Thus, role-power expansion in hierarchical contexts can produce the desired effect of overcoming relational inertia but ignites more contentious rather than collaborative interactions, a response consistent with increased tension and status renegotiation in reaction to greater power of the middle.

Our field experiment which examined the effect of expanding nurses’ roles to include care coordination for patients with complex needs at 12 health centers (6 intervention and 6 comparison) provided supportive evidence. In short, we found that the role expansion contributed to the development of a network structure consistent with the planned change goals (more coordinated care for patients via more ties between group members and streamlined networks), but also a structure that threatened groups’ ability to perform well overall due to the nature of the interactions within the new structure. We observed an escalation in what are generally considered problematic conversational behaviors for collaboration - decreased listening and increased interruptions - by group members across the professional hierarchy. Ironically, a more centralized formal and informal structure created more distributed interactions and conversational dynamics consistent with the theory that middle role expansion catalyzes status tension and conflicts, a potential explanation for why no significant improvement in patient care followed the implementation of nurse care coordination in these centers, per organizational analysis.

This work makes several noteworthy contributions. First, it advances our understanding of the interplay of formal and informal organization, and in doing so, develops our theoretical and practical knowledge of relational inertia and the evolution of interactions in organizations. The
majority of past work on the relationship between formal and informal organization has taken one of three approaches: (1) treating the formal organization as a control variable when studying relationships among informal structure and outcome variables; (2) treating formal organization as a boundary condition that shapes the effect of informal organization on outcomes; or (3) examining their combined effect on outcomes variables (McEvily et al., 2014). Our study contributes to work in an emerging fourth category focused on their influences on each other by illuminating how a shift in a key aspect of formal organization, work-role design, shifts network structure and interactions within hierarchical groups. In doing so, we respond to calls:

to study the origins and evolution of organizational interactions by jointly considering their formal and informal bases...[and] develop a body of knowledge that explores the mechanisms through which informal relationships emerge (or fail to emerge) as a consequence of changes in organizational design...to obtain a richer and more realistic portrayal of organizations (McEvily et al., 2014: 334,302).

Our findings indicate that formal organizational change via work-role redesign is a way in which relational inertia can be overcome. While it is perhaps unsurprising that a formal role change can induce changes in informal organizational networks, the complexity of interactions that emerge when this change occurs was unanticipated and has important implications for understandings of hierarchies. Expanding the role of the middle caused unexpected patterns to emerge - both in the structure and nature of interactions - possibly because it induced status renegotiation and tension.

Structurally, because of their role expansion, we expected that the middles/nurses would not just become less constrained (as they did) but also develop additional relationships as a function of their new coordination role. Instead, the lowest-ranking group (medical assistants) became the most central actors in the teams. One explanation is that the medical assistants pursued more ties
across the hierarchy in order to manage organizational and relational ambiguity (Reagans & McEvily, 2003; Saint-Charles & Mongeau, 2009; Srivastava, 2015b) and leverage the restructuring to elevate their position socially through newly possible relations. In this scenario, they pursued relationships to feel more a part of the team and enjoy the benefits of “status leakage” (Podolny, 2010) by associating with higher status others (Magee & Galinsky, 2008).

A second explanation is that medical assistants became most central and took on more of a brokerage role, despite retaining the lowest rank in the hierarchy, because the middle role expansion inherently pushed PCPs and nurses to rely on them more. In studying community health workers, Kellogg (2014) found that these lowest-status members in her setting took on spillover tasks as brokers once a role change for two higher status groups (doctors and lawyers) occurred; the higher status groups embraced this because it allowed them to main their professional jurisdiction, avoid status threat, and focus on core tasks. Our follow-up conversation with the study centers suggests that both mechanisms – lower status members exploiting status ambiguity to pursue relationships with higher status others, and the others pushing interactions toward them as brokers for formal task and status threat avoidance purposes – were at play.

The widespread escalation of contentious communication and interactions further shows the depth of the interplay of the formal and informal, and suggests that status tension may play an important role in generating relational inertia and thwarting change efforts within organizations. Structurally, we observed a significant decrease in PCP-nurse interactions, consistent with the notion that the intervention facilitated or generated separation, expected when status tension arises. The formal role-power expansion for the middle also had an effect on the deeper, nature of interaction, which is emergent rather than formally prescribed. It unexpectedly generated new communication behaviors across the entire professional hierarchy that undermines
collaboration (Lovelace, Shapiro, & Weingart, 2001). Problematic communication may have spread as much as it did because the formal change occurred at the middle of the hierarchy, allowing effects to cascade through all parts of the network.

Second, our study advances understandings of social networks. While a large body of work has examined the question, “How does network structure matter?” comparatively little work has examined “How do network structures change?” Our work contributes the growing body of research on network dynamics by documenting a mechanism by which network structure can change. Importantly, this study also shows the potential utility of using wearable social sensors to study the role that unanticipated consequences generated by micro-level social interactions can have in mediating planned change initiatives. Wearable sensors allow network researchers to move beyond focusing on outcomes, to studying process since they collect face-to-face network data at a level of temporal granularity that was previously impossible. Finally, how network members interact has received limited attention previously. Our work shows that the nature of social interactions, as evidenced by interruptions and listening, is as important and can be as dynamic as the structure of interactions themselves.

Third, our research expands study of “the middles” in professional hierarchies. For the most part, prior organizational work on “middles” has focused on the middle manager, providing many insights about the advantages and disadvantages being a middle manager, the roles within this role (Bryant & Stensaker, 2011), how their informal social structure affects their outcomes (Rodan & Galunic, 2004), and practices that should be applied to them versus other managers (Krausert, 2014). While much has been learned about this one type of middle, the experience and effects of non-managerial middles has been neglected, despite most workers not being managers and knowledge that managers’ work lives often differ from frontline workers’. Our work adds to
research on the middles by examining non-managerial middles, their relations to others and how their status gains change workgroup dynamics for all. The impact that we observed of their role expansion indicates that this group is worthy of continued investigation in order to better understand group dynamics, a view also expressed by others (e.g., Phillips & Zuckerman, 2001).

Fourth, this work contributes in a practical way to healthcare management as expansion of the nursing role to include care coordination is being considered internationally as a strategy for improving healthcare. The Institute of Medicine (2010) estimated that such coordination initiatives could result in $240 billion in savings and substantial improvement in the quality of care delivered to U.S. patients. Our results may explain why the cost-quality gains have been illusive for some organizations using nurse care coordination as their strategy, as reflected in the mixed results for past studies assessing effects. Our findings suggest that the virtue of this role re-design in principle can be undermined by the nature of the interactions fostered by this change within the hierarchical environment of medicine. Our data indicate that the role expansion for nurses escalates contentious rather than collaborative communication, which is foundational for deriving the benefits of interprofessional teamwork (Lovelace et al., 2001). This implies that a key task for healthcare managers that seek to implement nurse care coordination is to take steps to prevent the propensity to devolve into contentious interactions when relative power shifts. Research has found that delegating implementation to an improvement team representative of those affected facilitates successful implementation of role changes (Nembhard, Morrow, & Bradley, 2015). Likewise, having the team and other leaders model collaborative communication, establish the norm for such, and hold all accountable for their communication behavior is associated with more collaborative interactions (Detert & Burris, 2007; Edmondson, 2003). Together, these actions increase the likelihood that team representatives convey the
change in a way that promotes collaboration rather than intergroup conflict, and others respond similarly. Future research might identify other ways to counteract the negative consequences of role expansion so that the positive ones may be realized. These lessons are not only relevant for healthcare but should be instructive for all organizations that seek to implement changes that are likely to disrupt informal interactions in a manner that initiates status conflict.

Limitations with Suggestions for Future Research

Although our study advances research and practice in many ways, it is not without limitations. First, our data was collected from a small number of centers affiliated with one organization in one industry. While the study design and sample size allowed for more detailed data collection and the feasibility of field experiment, its scope raises the issue of generalizability. We expect that our findings apply to other settings inside and outside of healthcare in which clear (low-middle-high) hierarchies exist. Still, future research should seek to include many more organizations in other industries. Second, although participation rates of 62% and 72% are high for a field experiment conducted with busy healthcare professionals and meets the informal threshold of 60% for healthcare, we ideally would have liked complete network data. Third, although the wearable sensors provided much insight about face-to-face interaction, which would otherwise be difficult to collect, the data they provide do not cover all relevant aspects of communication. Content and electronic communication are missing. Lack of content was an advantage in our setting (for compliance with federal law), however, content is important. Also, in a time when people often communicate electronically, we may have missed key interactions by focusing on face-to-face communication, although it was a primary means of interaction in this organization. Future research should expand upon our work by incorporating electronic interactions in assessment of social network measures, and compare face-to-face to
electronic networks following role change, as they may differ, providing additional insight.

Beyond addressing the methodological limitations of our study, we hope that future research will expand on our study in several ways. Ideally, it will extend the time period for follow-up. Seven months of follow-up after the role change was sufficient for us to observe significant changes in who and how caregroup members interacted. Future work should incorporate a third time period to assess the inertia of the interactions that we observed. We also hope that future work will examine whether the found changes are associated with staff outcomes such as satisfaction and turnover, and also patient outcomes such as patient health and experience. This will require a longer follow-up period, particularly for patient outcomes. This extension would also help to advance our understanding of the interplay of formal and informal organization on performance (McEvily et al., 2014).

Our work demonstrates that efforts to change either formal organizational structures, or intraorganizational social networks, must attend to existing status hierarchies within organizations. In addition, our study underscores the potential of using wearable social sensors to study changes in network structure and the unexpected consequences that micro-level social interactions can have in mediating organizational change initiatives. By paying greater attention to the micro-dynamics of social interactions, we not only gain a better understanding of the processes generating anticipated and unanticipated behaviors in social interactions, we can also develop more appropriate interventions to redesign jobs and organizations. Within the realm of healthcare, this can help improve care coordination, reduce healthcare costs, and potentially save lives.
REFERENCES


### TABLE 1

Participants at Baseline and Follow-up in Intervention and Comparison Sites

<table>
<thead>
<tr>
<th>Participants</th>
<th>Baseline</th>
<th></th>
<th>Follow-up</th>
<th></th>
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<td>Intervention (N = 167)</td>
<td>Comparison (N = 237)</td>
<td>Intervention (N = 171)</td>
<td>Comparison (N = 216)</td>
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<td>0.32</td>
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<td>0.82</td>
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PCP = Primary Care Provider; N = person-days, the unit of analysis in our study
# TABLE 2

**Network Position and Conversational Characteristics in Intervention and Comparison Sites at Baseline and Follow-up**

<table>
<thead>
<tr>
<th>Variable</th>
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<th></th>
<th>Follow-Up</th>
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<th>Comparison</th>
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<tr>
<td></td>
<td>Mean</td>
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<td>Mean</td>
<td>S.D.</td>
<td>p-value</td>
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<td><strong>Overall</strong></td>
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<tr>
<td>Betweenness centrality</td>
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<td>0.23</td>
<td>0.64</td>
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<tr>
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<td>0.13</td>
<td>0.46</td>
<td>0.13</td>
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<td><strong>Intervention</strong></td>
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<tr>
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<td>(0.08)</td>
<td>(0.01)</td>
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Site fixed effects: Yes Yes Yes
Number of persons: 163 168 166
Total N (person-days): 701 692 688

*p<0.05; **p<0.01; ***p<0.001; Standard errors clustered by participant.
TABLE 4

Results of Regressions Predicting Conversational Characteristics

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<th>Interruptions</th>
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<td>Role intervention group X Time period</td>
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<td></td>
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<tr>
<td>Intercept</td>
<td>49.07***</td>
<td>2.38***</td>
</tr>
<tr>
<td></td>
<td>(3.00)</td>
<td>(0.72)</td>
</tr>
<tr>
<td>Site fixed effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of persons</td>
<td>173</td>
<td>176</td>
</tr>
<tr>
<td>Total N (person-days)</td>
<td>665</td>
<td>760</td>
</tr>
</tbody>
</table>

*p<0.05   **p<0.01   ***p<0.001; Standard errors clustered by participant
FIGURE 1

Effect of Role Change on Degree Centrality and Constraint by Profession

Figure 1a. Predicted degree centrality by profession for providers exposed (black) and unexposed (grey) to role expansion. * Indicates difference significant at p<0.05

Figure 1b. Predicted network constraint by profession for providers exposed (black) and unexposed (grey) to nurse coordination intervention. * Indicates difference significant at p<0.05.