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Coordinating Mechanisms in Care Provider Groups: Relational Coordination as a Mediator and Input Uncertainty as a Moderator of Performance Effects

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This paper proposes a model of how coordinating mechanisms work, and tests it in the context of patient care. Consistent with organization design theory, the performance effects of boundary spanners and team meetings were mediated by relational coordination, a communication- and relationship-intensive form of coordination. Contrary to organization design theory, however, the performance effects of routines were also mediated by relational coordination. Rather than serving as a *replacement* for interactions, as anticipated by organization design theory, routines work by *enhancing* interactions among participants. Likewise, all three coordinating mechanisms, including routines, were found to be increasingly effective under conditions of uncertainty.
(*Coordinating Mechanisms; Boundary Spanners; Routines; Relational Coordination; Input Uncertainty; Performance*)

Introduction

Coordination, the management of interdependencies among tasks (Malone and Crowston 1994), is believed to be critical for organizational performance. Indeed, one of the reasons given for the existence of organizations is that they enable coordination to occur more readily than can be achieved in their absence (Coase 1937, Kogut and Zander 1996). Well-coordinated work processes are expected to produce higher-quality outcomes, and to do so more efficiently. This phenomenon has been observed in a wide array of settings, including research and development (Allen 1984, Tushman 1979), new product development (Clark and Fujimoto 1991, Iansiti and Clark 1994), apparel production (Abernathy et al. 1999), air travel (Gittell 2001), and healthcare delivery (Argote 1982, Shortell et al. 1994, Young et al. 1998, Gittell et al. 2000). However, the question remains—what is the best way for organizations to *achieve* coordination?

Organization design theory suggests several alternatives. Coordination can be achieved through a variety of formal coordinating mechanisms, ranging from low bandwidth to high bandwidth (March and Simon 1958, Galbraith 1973, Tushman and Nadler 1978). Boundary spanners and team meetings have high bandwidth or information-processing capability, and are expected to work by *facilitating* interaction among participants in a work process. Work routines have low bandwidth or information-processing capacity, and are expected to work by *reducing the need* for interaction among participants. Consistent with their different bandwidths, boundary spanners and team meetings are expected to be increasingly effective as the level of uncertainty increases, while work

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routines are expected to be decreasingly effective. These expectations derive from the theory of requisite variety, which suggests that the information capabilities of coordinating mechanisms should match information requirements of the task at hand (Galbraith 1973). Because information requirements are increased by uncertainty, coordinating mechanisms with a broader bandwidth for transmitting information should become more effective in the face of uncertainty relative to those with narrower bandwidths (Daft and Lengel 1986).

In this paper I develop a model of how coordinating mechanisms work. I test this model in a healthcare setting where a broad range of coordinating mechanisms are in use, including routines in the form of clinical pathways, boundary spanners in the form of primary nurses and case managers, and team meetings in the form of patient rounds. In healthcare settings, input uncertainty exists due to differences among the patients themselves and is expected to increase the effectiveness of some coordinating mechanisms while decreasing the effectiveness of others (Argote 1982). Some of my findings support organization design theory, while some call it into question. The result is a refinement in our understanding of how coordinating mechanisms work.

Coordinating Mechanisms

Routines. Routines facilitate coordinated action by prespecifying the tasks to be performed and the sequence in which to perform them. Routines capture the lessons learned from previous experiences, enabling a process to be replicated without reinventing the wheel (Levitt and March 1986). By using routines to codify best practices, individual capabilities can be transformed into organizational capabilities, and therefore into potential sources of competitive advantage (Nelson and Winter 1981). Total quality management relies heavily on the use of standardized work to capture and implement previous learning and thereby to create a platform for further improvements (Deming 1986, Adler and Borys 1996). In healthcare settings, routines have long existed in the form of protocols. More recently, protocols have evolved into clinical pathways, which combine protocols used by different members of the care provider team into a single document, outlining the tasks to be completed and decisions to be made by each function, and the sequence in which they are to be performed. Although they have been derided by some physicians as "cookbook medicine" (Gittell 1998), clinical pathways are increasingly used for coordinating work processes in healthcare settings (Bohmer 1998).

According to organization design theory, routines work by reducing the need for interaction among participants and are therefore a relatively low-cost way to coordinate work. Because routines have low bandwidth, however, they are expected to be decreasingly effective under conditions of uncertainty (Tushman and Nadler 1978, Galbraith 1973). Although there is little or no evidence to show that routines improve performance by reducing the need for interaction, there is some empirical evidence to suggest that routines work best in low-uncertainty settings. Much of this evidence, however, takes the form of greater observed use of routines in low-uncertainty settings (Aiken and Hage 1968, Van de Ven et al. 1976, Keller 1978), leaving the performance effects unexplored. Others have found evidence that performance is positively associated with congruence between the degree of uncertainty and the coordinating mechanisms in use (Lawrence and Lorsch 1967, Khandwalla 1974). Consistent with those studies, Argote (1982) found that input uncertainty decreased the effectiveness of routines. Others have found no contingency effects. Pennings (1975), for example, found only weak support for the performance effects of fit between environmental and structural variables.

Boundary Spanners. Boundary spanners, also known as cross-functional liaisons, are individuals whose primary task is to integrate the work of other people (Lawrence and Lorsch 1967, Galbraith 1973). They integrate work that crosses functional boundaries, whether that work takes the form of a project, process, product, or provision of services to a particular customer (Davenport and Nohria 1994). Project managers are a common form of boundary spanner in product development settings (Allen 1984, Clark and Wheelwright 1992). In healthcare settings, boundary spanner roles include case managers and primary nurses. Case managers are staff members responsible for coordinating the care of the patients assigned to them. In some hospitals, nurses play a coordination role through a model called primary nursing. Primary nursing is a staffing model in which patients are assigned to a single nurse for the duration of their stay. The primary nurse is only one of many who actually provide care to the patient, but the primary nurse is responsible for coordinating the care of the patient from beginning to end of the stay.

According to organization design theory, boundary spanners increase performance of interdependent work processes by facilitating interaction among participants in a work process, and are increasingly effective under conditions of high uncertainty (Galbraith 1973, Tushman and Nadler 1978). Although there is little or no empirical evidence that boundary spanners improve performance by facilitating interaction among participants, some have found empirical evidence supporting the proposition that boundary spanners are increasingly effective as uncertainty increases (Lawrence and Lorsch 1967, Khandwalla 1974). This evidence, however, has taken the form of observed correlations between the degree of uncertainty and the use of boundary spanners rather than testing whether indeed boundary spanners are more effective in high uncertainty settings.

Team Meetings. Team meetings give participants the opportunity to coordinate tasks directly with one another. Meetings in the healthcare setting take the form of patient rounds, a long-established practice in hospitals in which the providers involved in the care of a particular patient discuss that patient's case, either at the bedside or in a separate conferencing area. According to organization design theory, team meetings increase performance of interdependent work processes by facilitating interaction among participants and are increasingly effective under conditions of high uncertainty (Galbraith 1973, Tushman and Nadler 1978). Although there is little or no evidence suggesting that team meetings improve performance by facilitating interactions, some have found empirical evidence supporting the proposition that team meetings are increasingly effective under conditions of high uncertainty (Lawrence and Lorsch 1967, Khandwalla 1974). This evidence, however, has taken the form of observed correlations between the degree of uncertainty and the use of team meetings rather than testing whether indeed team meetings are more effective in high uncertainty settings.

Relational Coordination

Beyond organization design theory, we find another view of coordination. If groups are sets of organizational members who must work interdependently to achieve a task designated by the organization (Alderfer 1977, Ancona 1987, Hackman 1987), and coordination is the management of interdependence (Malone and Crowston 1994), then coordination is arguably a central element of what effective groups do. From the perspective of group theorists and others who study the microdynamics of coordination, coordination may be facilitated by certain design elements but it is more fundamentally a process of interaction among participants. Organization design theorists noted the existence of this more spontaneous form of coordination and referred to it as "mutual adjustment" (Thompson 1967) and "teamwork" (Van de Ven et al. 1976). This form of coordination is distinct from all of the formal coordinating mechanisms identified in organization design theory because it refers to the interactions among participants rather than the mechanisms for supporting or replacing those interactions.

This more spontaneous form of coordination can be conceived as relational coordination (Gittell 2002). Relational coordination reflects the role that frequent, timely, accurate, problem-solving communication plays in the process of coordination, but it also captures the oft-overlooked role played by relationships. It has been argued that coordination does not occur in a relational vacuum; rather, coordination is carried out through a web of relationships (Gittell 2002). Specifically, coordination is carried out through relationships of shared goals, shared knowledge, and mutual respect, or conversely through relationships that are characterized by the *lack* of shared goals, shared knowledge, and mutual respect. Strong relationships enable employees to embrace their connections with one another, in turn enabling them to more effectively coordinate the work processes in which they are engaged. Shared goals motivate employees to move beyond subgoal optimization and to act with respect to the overall work process. Shared knowledge informs employees how their tasks fit relative to other tasks in the work process, enabling them to act with respect to the overall work process. Respect for the work of others encourages employees to value the contributions of others and to consider the impact of their actions on others, further reinforcing the inclination to act with respect to the overall work process. This web of relationships in turn affects the frequency, timeliness, accuracy, and problem-solving nature of communication, enabling employees to effectively coordinate the work process in which they are engaged by decreasing the obstacles to coordination.

With high levels of relational coordination, participants in a work process are expected to more effectively manage their task interdependencies, enabling them to improve performance along both quality and efficiency dimensions. Some evidence has been found for the performance effects of relational coordination. In the context of flight departures, relational coordination among members of cross-functional flight departure groups was associated with better on-time performance, better baggage-handling performance, and fewer customer complaints, and with shorter scheduled gate times and higher staff productivity (Gittell 2001, 2002). In the context of hospital care, relational coordination among members of cross-functional care provider groups was associated with improved quality of care and reduced lengths of hospital stay (Gittell et al. 2000).

Other theorists have contributed to our understanding of the underlying dimensions of relational coordination, particularly the frequency of communication (e.g., Tushman 1979, Ancona and Caldwell 1992), but also the timeliness (Waller 1999), accuracy (O'Reilly and Roberts 1977) and problem-solving nature of communication (Rubinstein 2000, Stevenson and Gilly 1993), as well as relationships of shared goals (March and Simon 1958, Saavedra et al. 1993, Wageman 1995), shared knowledge (Dougherty 1992, Weick and Roberts 1993), and mutual respect (Rubenstein et al. 1971, Eisenberg 1990). Analogous to mutual adjustment (Thompson 1967) and teamwork (Van de Ven et al. 1976), this more spontaneous form of coordination is expected to be increasingly effective under conditions of uncertainty due to its fundamental flexibility and adaptability.

Mediating Effects of Relational Coordination

How can organization design theory and the theory of relational coordination be reconciled? In fact, the reconciliation is quite obvious. As explained above, boundary spanners and team meetings are thought to work by *facilitating* interaction among participants (Galbraith 1973, Tushman and Nadler 1978)—and therefore are expected to improve performance through their effect on relational coordination. Routines, by contrast, have been argued to work by *reducing the need* for interaction among participants (Galbraith 1973, Tushman and Nadler 1978)—and therefore are expected to affect performance independently of relational coordination. This reasoning suggests the following three hypotheses:

HYPOTHESIS 1A. *Routines improve performance independently of relational coordination.*

HYPOTHESIS 2A. *Boundary spanners improve performance through their effects on relational coordination.*

HYPOTHESIS 3A. *Team meetings improve performance through their effects on relational coordination.*

In the resulting model of coordinating mechanisms and performance, relational coordination is expected to mediate the performance effects of boundary spanners and team meetings, while routines are expected to influence performance directly.

Moderating Effects of Uncertainty

Uncertainty is the lack of information relative to requirements (Daft and Lengel 1986). Uncertainty therefore increases when the amount of information decreases or when information requirements increase. Comstock and Scott (1977) argued for the importance of specifying the type of uncertainty under question, given the possibility that these types will have different impacts on the effectiveness of organizational structures. Environmental uncertainty is uncertainty arising from the external environment (Lawrence and Lorsch 1967, Pennings 1975), task uncertainty is uncertainty regarding performance of the task (Mohr 1971, Galbraith 1973, Van de Ven et al. 1976, Schoonhoven 1981), while input uncertainty is uncertainty regarding inputs to the production process. Specifically, input uncertainty is a function of the number of input possibilities in a given production process (Argote 1982). An increase in the number of input possibilities for a given production process increases information requirements.

As noted above, input uncertainty is particularly relevant in healthcare settings due to variation among the patients themselves. We therefore frame our hypotheses regarding the moderating effects of uncertainty in terms of input uncertainty. As argued above, input uncertainty is expected to reduce the performance effects of coordinating mechanisms with low bandwidth and to increase the performance effects of coordinating mechanisms and processes with high bandwidth.

HYPOTHESIS 1B. *Input uncertainty reduces the performance effects of routines.*

HYPOTHESIS 2B. *Input uncertainty increases the performance effects of boundary spanners.*

HYPOTHESIS 3B. *Input uncertainty increases the performance effects of team meetings.*

HYPOTHESIS 4. *Input uncertainty increases the performance effects of relational coordination.*

As noted above, there has been mixed evidence regarding the contingency effects of task conditions like uncertainty on structural elements like coordinating mechanisms. However, Schoonhoven (1981) has argued that findings have been mixed in part because contingency hypotheses have not been clearly specified empirically. Contingency hypotheses should be specified explicitly as interactive relationships, in either multiplicative or other forms, depending on the nature of the contingency hypothesized. Note that Hypotheses 1b through 4b are contingency hypotheses and are explicitly stated in a multiplicative form consistent with arguments by Schoonhoven (1981).

Methods

This study of coordinating mechanisms and performance was conducted in a healthcare setting. Within healthcare, I chose a work process for which outcomes are readily measured and whose correlates are relatively well understood: surgical care for joint replacement patients in acute-care hospitals. I selected nine hospitals that perform relatively large numbers of joint replacements to secure an adequate sample of patients in a short period of time. Each hospital has one cross-functional care provider group responsible for delivering care to joint replacement patients, made up of physicians, nurses, physical therapists, case managers, and social workers. The model developed above is tested at the level of the work group rather than the organization as a whole, given that the relevant variables are not likely to be homogeneous throughout an organization (Comstock and Scott 1977).

Data Sources

Data from the participating hospitals included telephone interviews of hospital administrators, a care provider questionnaire, a patient questionnaire, and patient hospitalization records. The hospital administrator interviews were used to measure coordinating mechanisms. The care provider questionnaire was used to survey care providers about relational coordination. The patient questionnaire and hospital administrative records were used to measure performance independent of supervisor or self-assessments. The patient questionnaire was also used to measure input uncertainty.

To assess the coordinating mechanisms in use at each hospital, phone interviews were conducted with a total of 45 hospital administrators from both centralized hospital departments and the care provider groups themselves. Questions were factual in nature, rather than perceptual, were asked in a standard format, and were asked of multiple respondents within each hospital. To measure relational coordination, I sent questionnaires to all eligible care providers in the five core functions who had clinical or administrative responsibilities for joint replacement patients during the study period: physicians, nurses, physical therapists, social workers, and case managers. A key departmental administrator designated by the department chief identified all eligible care providers at each institution. The administrator was supplied written guidelines as to whom should be included (all providers from the above five functions who were directly or indirectly involved with providing care for joint replacement patients). Questionnaires were initially mailed to all eligible care providers during the second month of the study period, with one repeat mailing during the study period for nonrespondents. Providers were asked to comment on their day-to-day interactions with other care providers, regarding the care of joint replacement patients. I received responses from 338 of 666 providers, for an overall provider response rate of 51%.

The patient questionnaire (154 items) was adapted from a validated instrument that is widely used to assess the quality of care in healthcare settings (Cleary et al. 1991). Patients were selected at random from among those admitted to one of the nine hospitals between July and December 1997 for primary, unilateral total joint replacement with a diagnosis of osteoarthritis. All patients were mailed questionnaires between 6 and 10 weeks postdischarge. Nonrespondents were sent up to three questionnaires. I received responses to 878 of 1,367 questionnaires sent to patients in the target population, for a response rate of 64%. Hospital administrative records were obtained for each patient from hospital administrators. These records were used to determine length of stay for each patient, and to extract information regarding patient characteristics to use as control variables in models of performance. Each variable is described below.

Coordinating Mechanisms

Questions regarding coordinating mechanisms used for the care of joint replacement patients were specified as factual questions and were asked in telephone interviews of hospital administrators. Coordinating mechanisms were operationalized at the group level.

Routines. All groups in the study used clinical pathways designed for the care of joint replacement patients. Groups varied, however, in the percent of joint replacement patients for whom the clinical pathway was used throughout their stay. This percent appeared to vary primarily based on the degree of agreement that had been achieved among physicians in the group for the adoption of clinical pathways. I computed for each group a variable called *routines* equal to the percent of joint replacement patients for whom the clinical pathway was used throughout their stay. This variable reflects the intensity of use of this coordinating mechanism.

Boundary Spanners. All groups in this study used case managers, known in some hospitals as care coordinators, but these groups differed substantially in the number of patients that their case managers were responsible for. I computed for each group a variable called *boundary spanner 1*, equal to the number of case managers per hundred patients, reflecting the intensity of use of this coordinating mechanism. I also created for each group a variable called *boundary spanner 2*, with a value of one if the group used the primary nursing model and a value of zero if the group did not, reflecting the use or lack of use of this coordinating mechanism.

Team Meetings. The intensity of use of team meetings varied greatly across groups, captured by the number of disciplines that were regularly represented in patient rounds. Rounds always included a physician and nurse manager and in some groups also included a case manager, nurses, physical therapists, occupational therapist, social worker, nutritionist, or pharmacist. I computed for each group a variable called *team meetings*, equal to the number of functions that were reported to attend rounds "always" or "usually."

Relational Coordination

The process of coordination was conceptualized for this study as relational coordination. Relational coordination was measured via the care provider questionnaire. Respondents from each of the five functions believed to be most central to the care of joint replacement patients—physicians, nurses, physical therapists, social workers, and case managers[1]—were asked to answer questions with respect to

[1] Relational coordination was also measured with respect to four other internal functions, including preadmission interviewers, consulting physicians, anesthesiologists, and recovery room nurses, but ties with these parties were expected to be less critical to patient care outcomes and therefore were not included in this analysis. When these additional internal functions were included in the measure of relational coordination, all results remained significant, but coefficients were smaller and less significant.

each of the other functions. The questions reflected the seven dimensions of relational coordination: frequency, timeliness, accuracy and problem-solving nature of communication, as well as relationships of shared goals, shared knowledge, and mutual respect. Items included the following: "How frequently do you communicate with each of these [functions] about the status of joint replacement patients?", "Do people in these [functions] communicate with you in a timely way about the status of joint replacement patients?", "Do people in these [functions] communicate with you accurately about the status of joint replacement patients?", "When an error has been made regarding joint replacement patients, do people in these [functions] blame others or share responsibility?", "To what extent do people in these [functions] share your goals for the care of joint replacement patients?", "How much do people in these [functions] know about the work you do with joint replacement patients?", and "How much do people in these [functions] respect you and the work you do with joint replacement patients?" Responses were measured on a 5-point Likert's scale.

Questions were asked with respect to typical patterns rather than asking respondents to recall specific incidents, consistent with Freeman et al. (1987). The questions did not ask for retrospective reports; rather, they asked respondents to describe current working conditions. The focus on current working conditions was expected to ameliorate the well-known problem of retrospective response error. Except for frequency of communication, which is thought to be less value-laden, I asked all questions about the communication and relations of other functions with the respondent, rather than asking the respondent for self-reported communication and relationships with others. This approach was taken to ameliorate the well-known problem of socially desirable responses to survey questions (Rosenthal and Rosnow 1991). For example, respondents might overestimate the extent to which they share the goals of other functions to give a socially appropriate response, but may exhibit more variation in their assessments of the extent to which members of other functions share their goals.

Each dimension of relational coordination was then computed as the percent of cross-function connections that are strong (i.e., 4 or 5 on a 5-point scale) on the expectation that groups are more clearly distinguished by the percent of strong connections than by the average strength of connections. I calculated the strength of the connections between each individual respondent and each of the five functions he or she was asked about, on each dimension of relational coordination. This resulted, for example, in a score for the frequency of communication between each nurse and the physician function, between each nurse and the therapist function, and so on for each of the five functions. I dropped the scores for connections between each respondent and his or her own function to maintain a focus on cross-function rather than within-function connections. This process resulted in a total of 28 scores for each respondent—seven questions regarding each of the other four functions.

Relational coordination is an equally weighted index of the responses to all seven questions. Cronbach's alpha for the index of relational coordination is 0.80. Using one-way analysis of variance, I found significant cross-group differences in relational coordination ($p = 0.0003$). An alternative measure of coordination, based on average strength of ties rather than the percent of strong ties, also varied significantly across groups, though less so ($p < 0.0007$).

Input Uncertainty

As described above, a significant source of uncertainty in healthcare settings is input uncertainty—differences among the patients themselves. Rather than variation in the primary diagnoses of patients, which was the key factor in the Argote (1982) study, this study focuses on a single patient population with a common primary diagnosis—osteoarthritic patients undergoing joint replacements. However, there is substantial variation among these patients due to differences in their secondary diagnoses, also known as comorbidities. Accordingly, clinical researchers have identified ten comorbid conditions that substantially complicate the care of joint replacement patients with osteoarthritis (Katz et al. 1996). These researchers developed a validated measurement instrument asking respondents to report whether they suffer from any of 10 comorbid conditions found to complicate the care of patients with joint replacements: heart disease, high blood pressure, diabetes, ulcer or stomach disease, kidney disease, anemia or other blood disease, cancer, depression, or back pain. These validated questions regarding comorbid conditions were included in the overall questionnaire mailed to patients for this study after their hospitalization. This patient self-report instrument was validated externally by testing degree of agreement between patient self-report and patient medical records, the source of patient medical information that is traditionally considered to be most reliable. The Spearman correlation coefficient between these two measures was 0.63 ($p < 0.0001$), with test-retest reliabilities of 0.91 and 0.92, respectively (Katz et al. 1996). In addition, I validated the comorbidities measure internally by testing its correlation with patient self-reports of overall health. The correlation between these two measures was -0.41 ($p < 0.01$).

A care provider group that experiences all 10 of these patient conditions in relatively equal portions is subject to greater input uncertainty than a care provider group that experiences one or two patient conditions in large proportions relative to the others. A patient coming into the first group is equally likely to have any of the 10 conditions, while a patient coming into the second group is most likely to have one of two conditions, reducing the input uncertainty experienced by the group. As Argote argued, "information theory suggests that, as volume homogeneity increases, input uncertainty increases. Conversely, as the volume of certain patient conditions becomes more or less than others, uncertainty decreases" (1982, p. 426).

I computed input uncertainty by computing for each of the 10 comorbid conditions the proportion of all comorbid conditions that each condition represented in a given care provider group. All comorbid conditions that were reported by each patient treated by a given group were used to compute that group's proportions. From these proportions, an overall mean was computed for each group. The input uncertainty measure is the inverse of the variance of the 10 proportions, so it is the frequency of each comorbid condition seen in the group that serves as the basis for this computation. Thus, the measure represents the similarity of the relative volumes of the 10 patient conditions for each group.

This measure of input uncertainty is therefore analogous to the measure of input uncertainty used in Argote (1982), with a couple of key differences. First, the measure used in this study addresses the secondary diagnoses that complicate treatment, rather than the primary diagnosis itself because the latter is uniform in this study by design. Second, the underlying measures of the frequencies of patient conditions were derived from patient self-reports in this study rather than from estimates by the nursing staff in the Argote study. Variance was measured in Argote (1982) based on nurses' estimates of the relative frequencies of 10 patient conditions using a survey instrument designed for the emergency room setting. By contrast, variance was measured for this study based on the relative frequencies of 10 patient conditions, as reported by patients using a survey instrument designed for the joint replacement setting. However, both measures were validated both internally and externally. Argote's perceptual measure of patient conditions was validated internally based on consistency across nurse respondents, and externally through correlations with perceptual measures from other sources. Similarly, the measure of patient conditions used here was validated internally based on its correlation with patient reports of overall health and externally based on its correlation with patient medical records as reported in Katz et al. (1996).

Performance

Following recommendations by Goodman et al. (1987), I used performance measures that were particularly relevant for the task of caring for patients in a hospital setting. Measures of performance for this study therefore included both patient-perceived quality and the efficiency of patient care. Believed to affect customer loyalty and likelihood to recommend, hospitals are interested in improving the quality of care as perceived by patients. Accordingly, all hospitals in this study had been conducting patient surveys for several years, though differences among the existing surveys required them to adopt a new patient survey for the purpose of this study.

I developed an index of the quality of care from the 25 survey items pertaining to the patient's acute-care experience. I excluded 10 items with the potential response: "not applicable," due to a large number of missing values. Those items were of the nature "Did you get answers you could understand from the physician?" with the response option "Did not have any questions for the physician." Including those items resulted in a biased subsample of respondents with more questions and problems than the typical respondent.

The 15 survey items that remained were the patient's reported: confidence and trust in his or her physicians, nurses, physical therapists, and case managers; having specific care providers in charge of his or her care; belief that providers were aware of his or her medical history; belief that providers were aware of his or her condition; belief that his or her providers supplied consistent information; belief that his or her providers worked well together; belief that he or she was treated with respect and dignity; satisfaction with his or her overall care; and finally, intent to recommend the hospital to others. An index with potential values from 1 to 5 was created from these items. Cronbach's alpha for this index is 0.844. Significant cross-group differences were found in patient-perceived quality of care ($p = 0.0000$), based on one-way analysis of variance.

Hospitals have also been striving to improve the efficiency of care by reducing patient lengths of stay and by reducing staffing per patient. The accurate measurement of staffing levels requires adjustment for skill level and is quite complex, but the length of stay is relatively straightforward. Length of stay is the number of inpatient days of care utilized by a given patient. Days of inpatient care are a resource that external payers are strongly focused on reducing. This study therefore uses the length of acute hospital stay as a measure of the efficiency of care. Length of stay was calculated from hospital records for each patient as the number of whole days between the date of admission and the date of discharge. Significant cross-group differences were found in hospital length of stay ($p = 0.0000$), based on one-way analysis of variance.

Control Variables

Control variables were selected for this patient population to adjust for factors that have been shown in the healthcare literature to affect the quality and efficiency of care for joint replacement patients. Control variables included the following patient characteristics: patient age, comorbidities, psychological well-being, preoperative status, surgical procedure (hip versus knee replacement), marital status, race, and gender. Patient age was determined from hospital records. Older patients were expected to require longer lengths of hospital stay. Preoperative clinical status was assessed in the patient survey using the pain and functioning elements of the WOMAC instrument (Bellamy et al. 1988). Patients with lower preoperative status were expected to require longer lengths of stay. Surgical procedure was measured through procedure code in the hospital record and was either a hip or a knee replacement. Knee replacements were expected to require longer lengths of stay, due to greater difficulty of achieving postoperative mobility. Psychological well-being was assessed in the patient survey using the mental health component of the SF-36 (Stewart et al. 1988). Patients with higher levels of psychological well-being were expected to report receiving higher quality of care: Psychological theory suggests that people with high levels of positive affect tend to perceive experiences in a more favorable light. Patient gender, race, and marital status were determined through the patient survey and were included in performance models because some studies have found demographic influences on healthcare outcomes.

Comorbidities were assessed in the patient survey with a series of questions asking patients whether they suffered from heart disease, high blood pressure, diabetes, ulcer or stomach disease, kidney disease, anemia or other blood disease, cancer, depression, or back pain (Katz et al. 1996). Individual patients with a greater number of comorbid conditions were expected to require longer lengths of hospital stay. Note that while comorbid conditions of individual patients are included as a control variable in the performance models, the group-level variability in those comorbid conditions is also included as an independent variable. Only the latter, group-level variability in comorbid conditions, reflects the concept of input uncertainty. In addition to patient characteristics, I measured the volume of joint replacements conducted by each group in the six-month period prior to the study period to control for possible scale effects (Luft 1990).

Data Analysis

Descriptive Data

Descriptive data for each of the nine groups are shown in Table 1, including the type of hospital each group belongs to and the city in which that hospital is located. Four of the groups belong to general hospitals, three belong to orthopedics specialty hospitals, and two belong to orthopedics specialty institutes located within general hospitals. Three of the groups are in New York City hospitals, four are in Boston hospitals, and two are in Dallas-area hospitals.

In addition, Table 1 shows group-level data on surgical volumes, input uncertainty, coordinating mechanisms, and levels of relational coordination among group members. The percent of patients for whom *routines* (clinical pathways) were used ranged from 70% for Group 3 to 100% for Groups 5, 6, and 7. Group 7 had the lowest use of *boundary spanner 1* (case management) of all groups, with 2.50 case managers per 100 patients, while Group 6 had the highest use, with 14.9 case managers per 100 patients. Five of the groups used *boundary spanner 2* (primary nursing model), while four did not. The number of functions that attended *team meetings* (patient rounds) regularly ranged from 2 in Groups 1 and 2 to 10 in Group 5. The level of *relational coordination* among group members ranged from 67% for Group 2 to 84% for Group 4. Group surgical volumes for the six-month period prior to the study ranged from 353 patients for Group 8 to 920 for Group 3.

Descriptive data for the sample as a whole and zero-order correlations for all variables are reported in Table 2. Pairwise deletion was used. Correlations among variables measured at the patient level of analysis are based on 644 to 809 patient-level observations, and a cluster technique was used to adjust p-values for group-level differences.

Table 1 Descriptive Statistics, by Group

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Total
Hospital characteristics										
Hospital type*	S/G	S	S	S	S/G	G	G	G	G	
Metropolitan area†	NYC	NYC	NYC	BOS	DAL	BOS	DAL	BOS	BOS	
Group characteristics										
Surgical volume	458	362	920	527	400	363	501	353	400	476
Input uncertainty	10.4	9.8	8.2	9.3	8.8	12.5	9.5	8.4	13.2	10.0
Routines	0.90	0.90	0.70	0.97	1.00	1.00	1.00	0.90	0.97	0.93
Boundary spanner 1	2.63	4.09	3.57	11.11	5.88	14.90	2.50	3.41	3.13	5.69
Boundary spanner 2	0	0	0	1	1	1	1	0	1	0.56
Team meetings	2	2	5	7	10	3	4	3	3	4.33
Relational coordination	0.72	0.67	0.73	0.84	0.80	0.81	0.76	0.77	0.76	0.76
Patient characteristics										
Quality of care	3.50	3.79	3.95	4.71	4.51	4.36	3.95	4.51	3.75	4.10
Length of stay (days)	5.6	5.8	5.9	4.4	4.2	4.4	5.6	4.3	5.0	5.1
Patient age	66.3	67.2	67.2	67.3	67.6	65.9	66.4	67.2	66.6	66.9
Comorbidities	1.5	1.7	1.4	1.4	1.3	1.7	1.6	1.5	1.7	1.5
Psych well-being	3.3	3.1	3.2	3.2	3.2	3.2	3.3	3.3	3.4	3.2
Preoperative status	47.3	39.9	46.1	47.5	47.3	45.3	43.6	48.6	47.1	45.8
Surgical procedure (% hips)	24	45	59	43	43	48	40	47	40	43
Marital status (% married)	64	52	73	62	77	50	68	65	63	64
Gender (% female)	61	66	58	50	60	49	62	63	58	58
Race (% black)	13	11	5	2	0	6	6	9	0	6

*G = general hospital, S = orthopedics specialty hospital, S/G = orthopedics specialty institute within a general hospital.
†NYC = New York City, BOS = Boston, DAL = Dallas.

Table 2 Descriptive Statistics and Correlation Table

	Obs	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Input uncertainty	9	10.0	1.8	—															
2. Boundary spanner 1	9	5.69	4.38	0.31	—														
3. Boundary spanner 2	9	0.56	0.53	0.44	0.49	—													
4. Team meetings	9	4.33	2.65	−0.42	0.22	0.48	—												
5. Routines	9	0.93	0.10	0.45	0.37	0.76^{*}	0.18	—											
6. Relational coordination	313	0.76	0.19	0.02	0.65^{+}	0.69^{*}	0.59^{+}	0.48	—										
7. Quality of care	644	4.10	0.64	−0.05	0.19^{*}	0.15^{+}	0.14^{+}	0.10^{+}	0.23^{**}	—									
8. Length of stay	809	5.11	2.13	−0.09	-0.30^{*}	-0.25^{+}	−0.12	-0.26^{*}	-0.34^{**}	-0.16^{**}	—								
9. Patient age	809	66.9	11.1	-0.03^{*}	−0.00	−0.01	0.01	−0.01	0.06	0.10^{*}	0.00	—							
10. Comorbidities	660	1.48	1.27	0.08^{**}	−0.00	0.00	−0.07	0.03	−0.37	−0.05	0.08	0.09^{+}	—						
11. Psych well-being	775	3.22	0.98	0.00	−0.02	0.02	−0.01	−0.00	0.26	0.16^{**}	-0.06^{*}	0.05	-0.33^{**}	—					
12. Preop status	724	45.8	20.1	−0.01	0.02	0.02	0.03	−0.00	0.63^{+}	−0.04	−0.02	0.09^{*}	-0.23^{**}	0.17^{**}	—				
13. Surgical procedure	809	0.43	0.50	−0.08	0.03	−0.01	−0.00	-0.10^{*}	0.12	0.05	−0.00	-0.10^{*}	-0.10^{**}	0.14^{+}	−0.09	—			
14. Marital status	795	0.64	0.48	-0.10^{*}	−0.08	−0.01	0.02	−0.06	0.15	0.10^{*}	0.04	-0.14^{**}	-0.11^{*}	0.12^{*}	0.12^{*}	0.05	—		
15. Gender	809	0.58	0.49	−0.03	−0.10	-0.06^{+}	−0.07	−0.02	-0.73^{*}	-0.07^{*}	0.06	0.03	0.08^{+}	-0.16^{**}	-0.26^{**}	−0.05	-0.34^{**}	—	
16. Race	809	0.06	0.24	0.01	−0.08	-0.13^{*}	−0.06	−0.04	-0.63^{+}	0.01	0.06	−0.03	0.12^{+}	-0.06^{+}	-0.08^{+}	−0.06	0.13^{*}	0.12^{*}	—
17. Surgical volume	9	510	186	−0.42	−0.18	−0.25	0.19	-0.78^{*}	−0.12	−0.05	0.22^{*}	0.01	-0.05^{*}	0.02	0.02	0.11^{*}	0.09^{*}	−0.02	−0.04

Note. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$.

Correlations between group-level and patient-level variables, and between group-level and provider-level variables, are based on 9 group-level observations.

Random-Effects Linear Regression

Note that the data for all measures of group performance were collected at the patient level. This allows the performance effects of coordinating mechanisms and relational coordination to be tested at the patient level of analysis, controlling for the effect of patient age, comorbidities, preoperative pain and functioning, surgical type, psychological well-being, gender, race, and marital status. Data for the measure of relational coordination were collected at the level of individual group members. This allows the effects of coordinating mechanisms on relational coordination to be tested at the level of the group member, controlling for the functional identity of the group member.

Random-effects regression analysis was used to adjust coefficients and standard errors for the multilevel nature of the data. To test the relationship between coordinating mechanisms, relational coordination, and performance, the patient is the unit of analysis with group ($n = 9$) as the random effect. To test the relationship between coordinating mechanisms and relational coordination, the group member is the unit of analysis with group ($n = 9$) as the random effect. Random-effects models, also known as mixed, hierarchical linear, or multilevel models, are an extension of fixed-effects models (Bryk and Raudenbush 1992, Hausman 1978). Unique to multilevel models, regression coefficients, standard errors, and the coefficient of variation (overall R squared) reflect statistical associations as measured both within and across groups.

Results

Relational Coordination as a Mediator of Performance Effects

Above, I proposed to integrate organization design theory with the theory of relational coordination. Building on arguments by Galbraith (1973) and Tushman and Nadler (1978), I hypothesized that boundary spanners and team meetings improve performance *through* their effects on relational coordination (Hypotheses 2a and 3a), while work routines improve performance by *reducing the need* for relational coordination (Hypothesis 1a). These mediation hypotheses required the testing of three equations: (1) the effects of coordinating mechanisms on performance, (2) the combined effects of coordinating mechanisms and relational coordination on performance, and (3) the effects of coordinating mechanisms on relational coordination. To show mediation, all of these effects must be significant, but the significance of the associations between coordinating mechanisms and performance must be reduced by adding relational coordination to the model (Baron and Kenny 1986).

The positive effects of coordinating mechanisms on quality and efficiency performance are shown in Table 3 (Columns 1a–8a). Routines are associated with increased quality of care (0.25, $p < 0.01$) and with reduced hospital lengths of stay (−0.23, $p < 0.01$), as expected. Boundary spanners are associated with increased quality of care (0.23, $p < 0.01$; 0.19, $p < 0.01$) and with reduced lengths of hospital stay (−0.28, $p < 0.01$; −0.20, $p < 0.01$), as expected. Likewise, team meetings are associated with increased quality of care (0.18, $p < 0.01$) and with reduced lengths of hospital stay (−0.26, $p < 0.01$). These findings suggest that all three coordinating mechanisms improve performance, consistent with organization design theory.

When relational coordination is added to each model of quality performance, the effects of coordinating mechanisms on quality performance become insignificant, while relational coordination itself has significant positive associations with quality performance (Columns 1b–4b). When relational coordination is added to each model of efficiency performance, the effects of coordinating mechanisms on efficiency performance are reduced or, in some cases, reversed, while relational coordination itself is associated with significant reductions in lengths of hospital stay (Columns 5b–8b). This evidence of mediation was expected for boundary spanners and team meetings, but not for routines, which were expected to affect performance directly.

To complete the mediation argument, it is necessary to show that coordinating mechanisms themselves are

Table 3 Relational Coordination as Mediator of the Performance Effects of Coordinating Mechanisms

	Quality of care							
	1a	1b	2a	2b	3a	3b	4a	4b
Routines	0.25**	−0.06						
Boundary spanner 1			0.23**	0.12+				
Boundary spanner 2					0.19**	−0.01		
Team meetings							0.18**	−0.02
Relational coordination		0.26**		0.15**		0.25**		0.25**
Input uncertainty	−0.19**	−0.14**	−0.23**	−0.19**	−0.22**	−0.15**	−0.09+	−0.16**
Patient age	0.00	−0.00	−0.00	−0.00	−0.00	−0.00	−0.01	−0.00
Preoperative status	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01	−0.02	−0.02
Comorbidities	0.08+	0.08+	0.08+	0.08+	0.07+	0.08+	0.08+	0.08+
Surgical procedure	0.12**	0.11**	0.10*	0.11**	0.11**	0.11**	0.11**	0.11**
Psych well-being	0.14**	0.14**	0.15**	0.15**	0.14**	0.14**	0.15**	0.14**
Gender	−0.05	−0.05	−0.04	−0.04	−0.05	−0.05	−0.05	−0.05
Race	0.01	0.03	0.01	0.02	0.02	0.03	0.02	0.03
Marital status	0.04	0.05	0.06	0.05	0.04	0.05	0.05	0.05
Surgical volume	0.18**	−0.01	−0.00	0.02	0.02	0.03	−0.01	0.02
Overall R square	0.09	0.12	0.12	0.13	0.10	0.12	0.10	0.12
	Length of stay							
	5a	5b	6a	6b	7a	7b	8a	8b
Routines	−0.23**	0.29**						
Boundary spanner 1			−0.28**	−0.08				
Boundary spanner 2					−0.20**	0.16*		
Team meetings							−0.26**	−0.01
Relational coordination		−0.43**		−0.26**		−0.43**		−0.30**
Input uncertainty	0.09*	0.01	0.14**	0.07	0.12*	−0.01	−0.04	0.04
Patient age	−0.02	−0.02	−0.02	−0.02	−0.02	−0.02	−0.02	−0.02
Preoperative status	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.04
Comorbidities	0.09*	0.08*	0.08+	0.08+	0.09*	0.08+	0.08+	0.08*
Surgical procedure	−0.00	0.00	0.01	0.00	0.00	−0.00	0.00	0.00
Psych well-being	−0.08+	−0.08*	−0.09*	−0.08*	−0.08+	−0.08+	−0.08+	−0.08*
Gender	0.07+	0.06	0.05	0.05	0.07	0.06	0.06	0.06
Race	0.05	0.03	0.05	0.03	0.04	0.03	0.04	0.02
Marital status	0.04	0.01	0.01	0.02	0.04	0.02	0.03	0.02
Surgical volume	0.06	0.38**	0.23**	0.19**	0.21**	0.19**	0.23**	0.18**
Overall R square	0.10	0.19	0.15	0.18	0.11	0.13	0.13	0.17

Note. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$. All models are random-effects linear regressions with group ($n = 9$) as the random effect. Patients are the unit of analysis with $n = 588$ for quality-of-care models and $n = 599$ for length-of-stay models. Standardized regression coefficients are shown.

Table 4 Effects of Coordinating Mechanisms on Relational Coordination

	Relational coordination			
	1	2	3	4
Routines	0.28**			
Boundary spanner 1		0.19**		
Boundary spanner 2			0.22**	
Team meetings				0.22**
Nurse	0.14*	0.16*	0.13+	0.16*
Physical therapist	0.21**	0.22**	0.22**	0.22**
Case manager	0.12*	0.13*	0.13*	0.12*
Social worker	0.05	0.03	0.03	0.02
Surgical volume	0.18*	−0.01	−0.00	−0.11+
Overall R square	0.09	0.09	0.10	0.09

Note. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$. All models are random-effects linear regressions with group ($n = 9$) as the random effect. Group members ($n = 313$) are the unit of analysis. Physician is the omitted function. Standardized regression coefficients are shown.

associated with increased levels of relational coordination (Table 4). As expected, boundary spanners (0.19, $p < 0.01$; 0.22, $p < 0.01$) and team meetings (0.22, $p < 0.01$) are each associated with higher levels of relational coordination. Contrary to expectations, routines (0.28, $p < 0.01$) are also associated with higher levels of relational coordination among participants.[2]

Input Uncertainty as a Moderator of Performance Effects

Organization design theory suggests that routines become less effective under conditions of input uncertainty (Hypothesis 1b), while boundary spanners and team meetings become increasingly effective (Hypotheses 2b and 3b). This moderation argument required testing two sets of equations: (1) the performance effects of each coordinating mechanism and input uncertainty, and (2) the performance effects of the coordinating mechanisms, input uncertainty, and their product. To show moderation, the product of the coordinating mechanism and input uncertainty must be significantly associated with performance (Baron and Kenny 1986). This approach is consistent with Schoonhoven's (1981) recommendation for operationalizing contingency hypotheses.

We see in Table 5 that the product of boundary spanner 1 and input uncertainty is not significant, contrary to Hypothesis 2b. However, as expected, we see that the product of boundary spanner 2 and input uncertainty is associated with higher quality of care (0.12, $p < 0.05$) and shorter lengths of hospitals stay (−0.19, $p < 0.01$), suggesting partial support for Hypothesis 2b. We also see that the product of team meetings and input uncertainty is significant in the expected direction for the quality of care (0.42, $p < 0.01$), but insignificant for the efficiency of care, providing partial support for Hypothesis 3b. Interestingly, we also see that the product of routines and input uncertainty is associated with increased quality of care (0.33, $p < 0.01$) and reduced lengths of hospital stay (−0.46, $p < 0.01$). This finding suggests that input uncertainty *increases* rather than reduces the quality and efficiency effects of routines, contrary to Hypothesis 1b.

As we also see in Table 5, relational coordination is associated with increased quality of care (0.23, $p < 0.01$) and with reduced lengths of hospital stay (−0.31, $p < 0.01$). In addition, the product of relational coordination and input uncertainty is associated with increased quality of care (0.14, $p < 0.05$) and reduced lengths of hospital stay (−0.20, $p < 0.01$), suggesting that input uncertainty increases the performance effects of relational coordination, consistent with Hypothesis 4b.

Summary of Findings

The data provide strong, consistent support for the positive performance effects of routines, boundary spanners, team meetings, and relational coordination. The data further suggest that formal coordinating mechanisms of all three types—boundary spanners, team meetings as well as routines—improve performance by increasing the level of relational coordination among participants (Hypotheses 1a, 2a, and 3a). This was not expected to be the case for routines.

[2] If relational coordination is measured using only its communication components (frequent, timely, accurate, problem-solving communication) and dropping its relationship components (shared goals, shared knowledge and mutual respect), the results reported in this paper remain unchanged, except that the coefficients on relational coordination are in most cases smaller and somewhat less significant.

Table 5 Input Uncertainty as Moderator of the Performance Effects of Coordinating Mechanisms

	Quality of care									
	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b
Routines	0.25**	0.44**								
Boundary spanner 1			0.23**	0.23**						
Boundary spanner 2					0.19**	0.21**				
Team meetings							0.18**	0.36**		
Relational coord								0.23**		0.23**
Input uncertainty	−0.19**	−0.39**	−0.23**	−0.23**	−0.22**	−0.30**	−0.09+	0.15	−0.16**	−0.19**
* Input uncertainty		0.33**		0.01		0.12*		0.42**		0.13*
Patient age	0.00	0.00	−0.00	−0.00	−0.00	0.00	−0.01	−0.00	−0.00	−0.00
Preop status	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01	−0.02	−0.01	−0.01	−0.01
Comorbidities	0.08+	0.07	0.08+	0.08+	0.07+	0.07+	0.08+	0.08+	0.08+	0.08+
Surgical procedure	0.12**	0.10*	0.10*	0.10*	0.11**	0.10*	0.11**	0.11**	0.12**	0.11**
Psych well-being	0.14**	0.14**	0.15**	0.15**	0.14**	0.14**	0.15**	0.14**	0.14**	0.14**
Gender	−0.05	−0.05	−0.04	−0.04	−0.05	−0.05	−0.05	−0.04	−0.05	−0.04
Race	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.03	0.03
Marital status	0.04	0.03	0.06	0.06	0.04	0.04	0.05	0.05	0.05	0.05
Surgical volume	0.18**	0.02	−0.00	−0.01	−0.01	0.02	−0.01	0.03	0.02	0.02
Overall *R* square	0.09	0.11	0.12	0.12	0.10	0.11	0.10	0.11	0.12	0.13
	Length of stay									
	6a	6b	7a	7b	8a	8b	9a	9b	10a	10b
Routines	−0.23**	−0.50**								
Boundary spanner 1			−0.28**	−0.25**						
Boundary spanner 2					−0.20**	−0.23**				
Team meetings							−0.26**	−0.32**		
Relational coord									−0.31**	−0.31**
Input uncertainty	0.09*	0.38**	0.14**	0.15**	0.12*	0.24**	−0.04	−0.13	0.05	0.12**
* Input uncertainty		−0.46**		−0.04		−0.19**		−0.15		−0.29**
Patient age	−0.02	−0.03	−0.02	−0.02	−0.02	−0.02	−0.02	−0.02	−0.02	−0.02
Preop status	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Comorbidities	0.09*	0.09*	0.08+	0.08+	0.09*	0.09*	0.08+	0.08+	0.08*	0.08*
Surgical procedure	−0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.00	0.00	0.01
Psych well-being	−0.08+	−0.08+	−0.09*	−0.09*	−0.08+	−0.08+	−0.08*	−0.08*	−0.08*	−0.09*
Gender	0.07+	0.07+	0.05	0.05	0.07	0.07	0.06	0.06	0.06	0.06
Race	0.05	0.03	0.05	0.05	0.04	0.03	0.04	0.04	0.02	0.02
Marital status	0.04	0.04	0.01	0.01	0.04	0.04	0.03	0.03	0.02	0.02
Surgical volume	0.06	0.28**	0.23**	0.23**	0.21**	0.29**	0.23**	0.23**	0.18**	0.26**
Overall *R* square	0.10	0.14	0.15	0.15	0.11	0.13	0.13	0.14	0.18	0.19

Note. $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$. All models are random-effects linear regressions with group ($n = 9$) as the random effect. Patients are the unit of analysis with $n = 588$ for quality-of-care models and $n = 599$ for length-of-stay models. Standardized regression coefficients are shown.

The data also provide partial support for the hypotheses that input uncertainty increases the effectiveness of boundary spanners and team meetings (Hypotheses 2b and 3b). In addition, the data fully support the hypothesis that input uncertainty increases the effectiveness of relational coordination (Hypothesis 4b). However, no support was found for the hypothesis that input uncertainty reduces the effectiveness of routines (Hypothesis 1b). Instead, input uncertainty appears to increase the performance effects of routines.

Discussion

These results suggest a revised model for how coordinating mechanisms work. The findings reported here suggest that routines, as well as boundary spanners and team meetings, work by strengthening relational coordination among participants. As opposed to coordinating mechanisms, which are structures that either facilitate interaction or reduce the need for it, relational coordination represents the process of interaction itself. The resulting structure/process/outcomes model goes beyond the literature and the existing theoretical framework by suggesting that coordinating mechanisms—even routines—improve performance by facilitating interaction among participants in the work process. Rather than reducing the need for relational coordination among participants, as theorized by Galbraith (1973) and others in the organization design tradition, routines were found to work only to the extent that they facilitated relational coordination. Similarly, the findings reported here call into question the theory that input uncertainty reduces the effectiveness of routines. Instead, input uncertainty appears to increase their effectiveness.

As noted above, the argument that coordinating mechanisms work by either supporting or replacing the need for interactions among participants has been theorized, but has not been subjected to empirical test in previous studies. However, the moderating effects of input uncertainty have been tested in previous studies. The primary conflict between my findings and prior findings is that input uncertainty was found here to increase rather than decrease the performance effects of routines. Perhaps this difference in results is due to differences in the measure of input uncertainty. Consistent with the measure of input uncertainty used in the landmark study of coordinating mechanisms in healthcare (Argote 1982), input uncertainty is measured here as the inverse of the variability in health conditions across the patients served by each care provider group. However, the health conditions considered here were secondary, or comorbid, conditions rather than primary conditions, given that all patients in this study had the same primary conditions. This measurement difference could have been expected to reduce the overall impact of input uncertainty, perhaps, but not to reverse its moderating effects.

Another notable difference is that Argote's study of coordination and input uncertainty was conducted in the context of emergency units, where overall levels of input uncertainty are expected to be far greater than in the joint replacement setting in which this study was conducted. However, the critical factor is differences in input uncertainty across units or groups *within* the context of each study, and there is no a priori reason to expect that emergency units encompass a wider range of input uncertainty than is encompassed by the groups caring for joint replacement patients. Finally, variability is measured for this study based on the relative frequencies of 10 patient conditions as reported by patients using a survey instrument designed for the joint replacement setting. By contrast, variability was measured in Argote (1982) based on nurses' estimates of the relative frequencies of 10 patient conditions using a survey instrument designed for the emergency room setting. However, both measures were validated internally and externally and conceptually are quite similar.

More likely, the differences in findings result from differences in the routines that were considered here. Routines in the Argote (1982) study took the form of rules, whereas routines in this study took the form of clinical pathways, a more recent arrival on the clinical scene (Bohmer 1998). Routines as a set of rules may not be particularly useful as uncertainty increases, but routines in the form of clinical pathways are different. They not only specify the standard operating procedures for each function—they also specify the links among the actions to be taken by each function. Clinical pathways are more like process maps in this sense, rather than lists of rules for behavior.

The theoretical implication of the findings reported here is that, despite their reliance on codification, and despite their narrower bandwidths (Daft and Lengel 1986), routines can be increasingly effective in the face of uncertainty. Perhaps this is because codification plays an important, underappreciated role in managing the complexity that accompanies uncertainty. Adler and Borys (1996) suggest that routines can be "designed to afford [participants] an understanding of where their tasks fit into the whole." More recent arguments by Feldman and Rafaeli (2002) suggest that routines are sources of connections and shared understanding among participants. If routines, through codification, enhance participants' understanding of the overall process and their own role in that process, then those mechanisms should be more rather than less effective as uncertainty increases. This interpretation is consistent with the finding reported here that routines improve performance by strengthening relational coordination, rather than by reducing the need for it.

This study has some limitations. First, one would ideally want a sample size larger than the nine groups included in this study. Although the use of patient-level data allows the sample size to be leveraged beyond the normal limitations of nine group-level observations, using random-effects modeling, still there is a limitation to the number of group-level variables that can be simultaneously included in the model. On the positive side, focusing data collection on nine groups facilitated the collection of data that closely reflect the process of care from the perspective of both care providers and patients. Second, though the moderated and mediated models that are developed and tested here have implications for causal direction, causal direction is still best tested through longitudinal rather than cross-sectional data. Third, quality of care was measured from the patient's rather than from the provider's perspective. Patient-assessed quality of care has not traditionally been considered to be a relevant outcome in healthcare settings. However, the patient perspective was validated through clinical work on patient-centered care (Gerteis et al. 1993) and has continued to grow in importance as a dimension of healthcare quality (Chilingerian 2000). Finally, although group member and patient response rates were reasonable for a mailed questionnaire (51% and 64%, respectively), both varied significantly by group. However, group member response rates by group were uncorrelated with measures of relational coordination. In addition, patient response rates by group were uncorrelated with measures of input uncertainty, quality of care, and length of stay. The lack of strong correlation between response rates and responses suggests that response bias is less likely to threaten the validity of the models' assumptions.

The managerial implications of these findings are simple but powerful. Routines, along with more interactive mechanisms like boundary spanners and team meetings, can be increasingly useful as levels of uncertainty increase. The findings reported here challenge the view that routines are less useful in the face of uncertainty due to their narrower bandwidths. Instead, routines in the form of process maps that provide common information to all participants in the work process should be embraced as tools for managing uncertainty, due to their apparent ability to enhance interactions among participants in the work process.

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